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Coal Transportation Practices and Equipment Requirements to 1985

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8706

Coal Transportation Practices and Equipment Requirements to 1985

By Gary M. Larwood and David C. Benson
Eastern Field Operation Center, Pittsburgh, Pa.

March 3, 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
Thomas S. Kleppe, Secretary

U.S. BUREAU OF MINES
Thomas V. Falkie, Director

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COAL TRANSPORTATION PRACTICES AND EQUIPMENT REQUIREMENTS TO 1985

by

Gary M. Larwood[1] and David C. Benson[2]

ABSTRACT

A study was conducted to determine the amount of transportation equipment required to move 1.2 billion tons of coal in 1985. The Federal Bureau of Mines has investigated a majority of the various practices associated with coal transportation and has gathered information on the regional origin-destination patterns, methods of movement, equipment stocks, rate structures, and operational capacities of the most important modes of coal haulage currently in use.

Models employing this information were developed to establish the origin-destination pattern for 1985 coal shipments, estimate practical tonnage capacities for selected coal hauling rivers, develop modal shares for both unconstrained (by river capacity) and constrained cases, and present a range of coal transportation equipment requirements for given sets of constraints.

Projected transportation shares for rail ranged from 63.7 to 72.3 percent, and for river, from 8.8 to 16.4 percent. Other coal transportation modes (truck, conveyor, Great Lakes, and tidewater) are expected to retain their historic shares of coal traffic.

Equipment estimates were made for 1985 rail and water transportation based on 1973 average and best practice. Average practice estimates ranged from 675,000 to 710,000 hopper cars (100-ton) and 3,100 to 5,940 barges (1,400-ton equivalent). Best practice estimates ranged from 126,000 to 142,000 hopper cars and 1,750 to 3,450 barges. Full implementation of 1973 best practice by 1985 is unlikely.

INTRODUCTION

Transportation has been identified as a possible constraint to the planned production and consumption of 1.2 billion tons (16)[3] of coal in 1985.

---

[1] Metallurgist.

[2] Physical scientist.

[3] Underlined numbers in parentheses refer to items in the bibliography that precedes the appendixes.

The Federal Bureau of Mines has recognized the need for developing an expanded and more efficient coal haulage network. Cooperation will be required among all sectors of transportation to achieve the Nation's goals to (1) overcome coal supply restrictions imposed by air quality standards, (2) introduce new areas of production to the coal consuming market, and (3) realize the economies afforded in the efficient transportation of bulk commodities. An understanding for the extent of expansion needed to meet these goals demands an estimation of the future transportation equipment requirements.

In prior studies (5, 16, 26, 29), these estimates were developed using a static approach. Usually the authors regarded a doubling in coal production as requiring a twofold increase in transportation equipment to reach needed capacity. In contrast, analyses of current trends and practices in transportation reveal that the various methods of hauling coal are constantly changing. Applying innovative techniques to existing practices and introducing completely new methods have lent a dynamic nature to coal transportation.

This study is concerned with identifying the major dynamic components to coal transportation and projecting their effect on 1985 coal traffic and equipment requirements. It entails a thorough scrutiny of coal transportation practices over the past 10 years, the development of a national origin-destination configuration for coal shipments in 1985, a presentation of inherent modal costs and effects of river capacity constraints, and the calculation of equipment requirements for select situations.

COAL TRANSPORTATION PRACTICES

There are six basic modes of transporting coal in the United States. Figure 1 illustrates the annual coal shipments from 1962 through 1974 (part A) and the shares of total shipments for all-rail (B), river and ex-river[4] (C); and truck, Great Lakes, conveyor, and tidewater modes (D).[5] Coal shipments have increased 43 percent during the period. The modal shares for rail have increased slightly between 1962 and 1974 (1.7 percent), while river and ex-river share of total shipments declined slightly (1.0 percent). Modal share growth was experienced by tramway and conveyors (4.4 percent) and trucks (3.9 percent), while Great Lakes (-5.0 percent) and tidewater (-3.9 percent) shares declined.

Rail Transportation

Rail is the primary method for coal transportation in the United States. All-rail movements totaled over 290 million tons in 1973, a 41 percent increase since 1962, and have maintained their share of the growth in shipments. The more than 40 class I railroads that carry coal can provide transportation to both large and small coal mining operations.

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[4] Terms are defined in appendix H.

[5] Statistics are from the U.S. Bureau of Mines Mineral Yearbook, an annual publication (54).

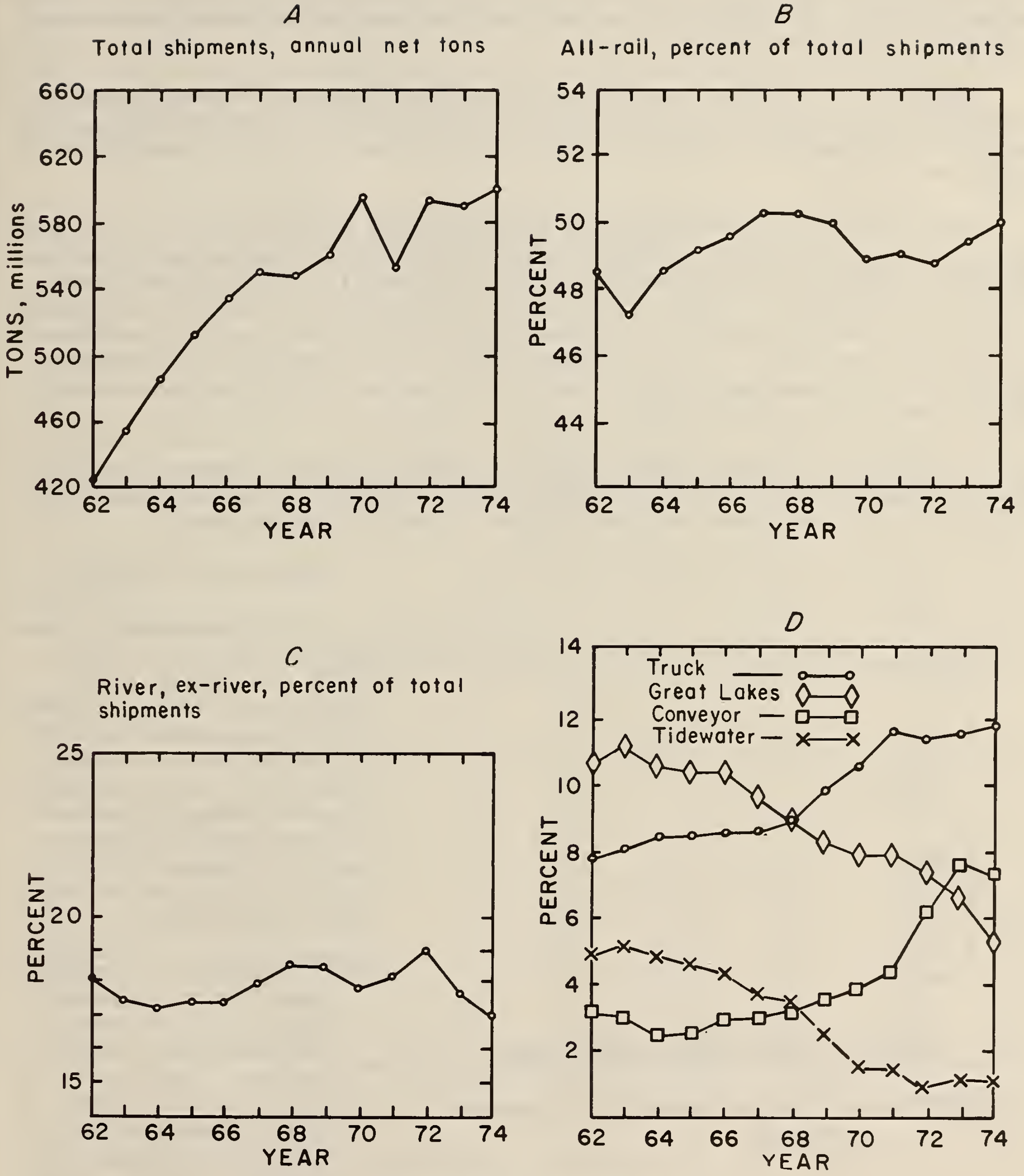

FIGURE 1. - Modal share coal shipments, 1962-74.

Methods of Rail Operation

Single car loading serves the smaller coal mines. Empty hopper cars are placed at the mine for loading as ordered. The railroad crew and motive units must make two trips for a few cars; thus crew efficiency and equipment utilization are low. In addition, the cars must be gathered and moved through a system of sorting terminals.

Multiple car loading, serving medium to large mines, provides somewhat better use of equipment than single car loading. But cars still must be sorted at intermediate terminals. Most coal shipped by rail is moved by multiple car loading.

Unit trains, the most efficient method of rail transportation, serve both medium and large mining operations. They require rapid loading and unloading facilities with the associated stockpiling and dedicated railroad equipment. From 1969 through 1973, unit train tonnages increased in 14 of 21 coal producing States. Table 1 provides a time series of unit train loadings by State. For those States east of the Mississippi River, there was only a 13-million-ton gain or 11.5 percent (1973 versus 1969). Western States gained nearly 20 million for a 350-percent gain.

Although unit trains require three to four times fewer hopper cars than used in single car loading, they moved only 39 percent of rail shipments in 1973 (54). (Fig. 2 shows the growth trend of unit train shipments.)

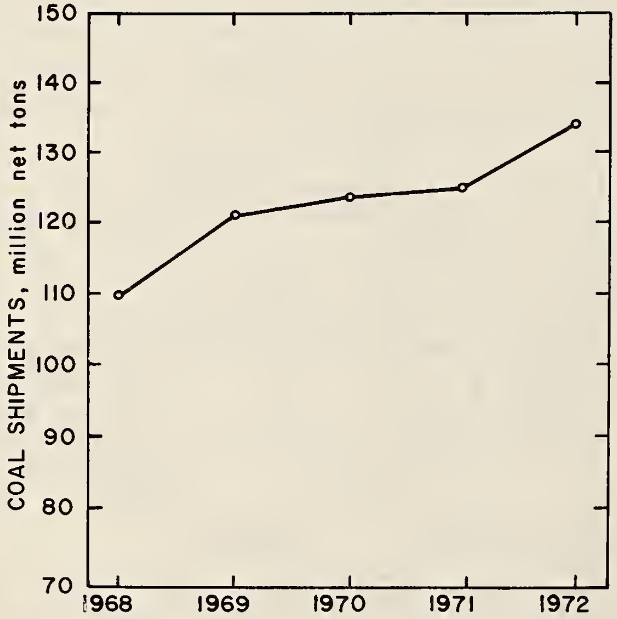

FIGURE 2. - Unit train movements of bituminous coal and lignite.

Hopper Car Ownership

Total ownership of open-top hopper cars by class I railroads has declined by 80,000 since 1964; the number of serviceable cars has dropped by nearly 73,000 (table 2).[6] Aggregate serviceable capacity, however, has increased slightly (table 2) because of a steady increase in average hopper car capacity

---

[6] There has been a trend for electric utilities and other coal consumers to purchase their own hopper cars. This trend may well continue in the future because of the advantages afforded in favorable rates and better car control. Electric utility ownership totaled 4,979 cars in 1974.

(fig. 3). The size of the hopper cars ranges from 50 to 110 short tons. Although a listing of the size distribution of hopper cars currently in the industry has not been published, the replacement size has increased gradually with time. This size distribution would be a good indication of car age. Railroads now are purchasing cars in the range from 80 to 110 tons per car. The current (November 1, 1974) order backlog for coal hopper cars is near 25,832 (11).

TABLE 1. - Unit train movements of bituminous coal and lignite

(Thousands of net tons)

State	1968	1969	1970	1971	1972	1973
Eastern:						
Alabama..............	-	2,257	3,088	3,373	4,253	3,930
Arkansas.............	-	40	-	89	-	-
Illinois.............	13,363	17,621	17,217	17,329	21,777	22,155
Kentucky East.........	8,537	7,420	9,361	11,164	9,522	12,197
Kentucky West.........	4,864	6,845	8,762	7,730	6,706	7,291
Total Kentucky.....	13,401	14,265	18,123	18,894	16,228	19,489
Maryland..............	-	150	232	210	60	122
Ohio..................	10,477	13,014	13,308	16,688	18,063	18,266
Pennsylvania..........	18,054	20,370	21,325	19,125	18,228	22,262
Tennessee.............	-	-	398	1,343	1,171	1,208
Virginia..............	5,372	5,067	5,861	2,525	3,301	4,477
West Virginia.........	42,289	40,733	30,110	26,793	33,446	34,203
Total eastern......	102,956	113,517	109,662	106,369	116,527	126,111
Western:						
Colorado..............	731	1,336	2,427	1,692	1,210	2,391
Indiana...............	(1)	1,913	2,997	2,351	3,048	5,493
Iowa..................	-	-	-	-	378	-
Kansas................	(1)	96	-	762	214	190
Missouri..............	-	365	-	-	-	-
Montana (Bitum.)......	1	2	3,022	6,526	7,698	10,115
New Mexico............	-	742	1,130	1,034	623	778
North Dakota (Lig.)...	-	787	916	923	1,577	1,607
Oklahoma..............	-	934	974	910	462	489
Utah..................	(1)	2,031	2,055	1,825	1,905	2,094
Wyoming...............	-	-	107	441	2,889	5,826
Other.................	5,435	-	-	-	-	-
Total western[2].....	6,167	8,206	13,628	16,464	20,004	28,983
Grand total[2].......	109,125	121,722	123,289	122,832	136,534	155,094

[1] Included in "Other."

[2] Totals may not add due to independent rounding.

Source: Bureau of Mines Minerals Yearbook (54).

TABLE 2. - Total ownership and aggregate serviceable capacity of open-top hopper cars by class I railroads

Year (as of January 1)	Total hopper car ownership	Hopper cars awaiting repairs	Serviceable hopper cars	Aggregate serviceable capacity, million short tons	Average car capacity, tons
1964..............	434,516	26,227	408,289	25.33	62.04
1965..............	434,234	25,943	408,291	26.07	63.84
1966..............	428,566	21,451	407,115	26.53	65.18
1967..............	428,970	17,706	411,264	27.50	66.87
1968..............	419,298	17,518	401,780	27.48	68.40
1969..............	410,508	17,558	392,950	27.53	70.05
1970..............	394,204	16,054	378,150	27.06	71.56
1971..............	388,492	14,983	373,509	27.23	72.89
1972..............	386,482	14,479	372,003	27.68	74.41
1973..............	373,136	17,865	355,271	26.99	75.98
1974..............	354,608	19,280	335,328	25.68	76.57

Source: Association of American Railroads (2).

Hopper Car Utilization

Each hopper car travels an average of 57 miles per day. At 20 miles per hour, the average car spends about 3 hours in transit. The remaining time is spent in sorting yards, terminals, loading/unloading facilities, etc.

The advantages of unit trains become even more apparent when considering the gains in intensity of equipment use. For example, a unit train probably can make a 300-mile haul and return in 1.5 days; that is an average of 400 miles per day including loading and unloading--a sevenfold increase over average practice. One car, making three trips per week in a unit train running 300 miles, would make 150 trips per year in a 50-week year or transport 15,000 tons (assuming car capacity at 100 tons). In contrast, the same car, with an average 14.36 days turn-around-time and a 300-mile haul (1973 average), would make 24 trips per year and transport

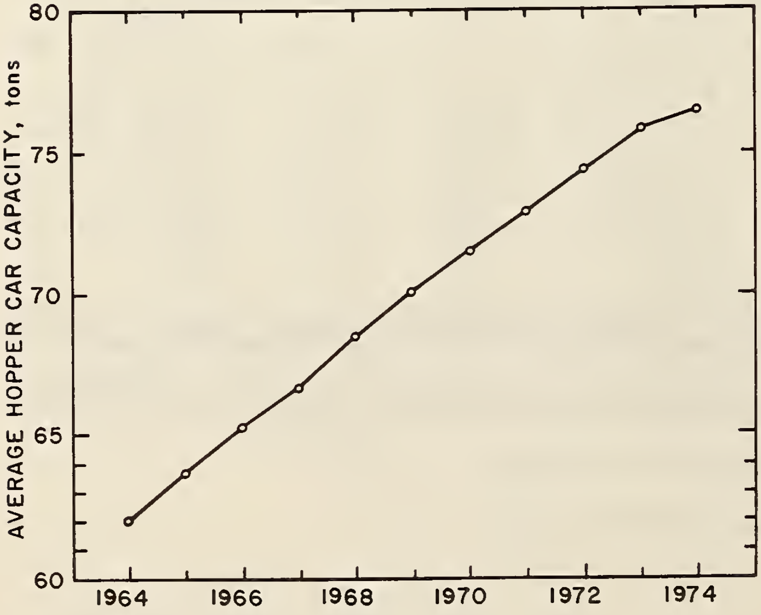

FIGURE 3. - Average open-top hopper car capacity.

2,400 tons per year. The case for using unit trains with dedicated equipment and rapid loading/unloading facilities for serving medium to large mining operations is strong indeed.

Coal Originating and Interlining

Table 3 lists coal movements handled by the major 15 coal carriers in 1973. Most of the roads (11 out of 15) hauled more originated tonnage than connecting tonnage; the five largest roads originated nearly 300 million tons--or 80 percent of tonnage originated by class I railroads in 1973.

TABLE 3. - Bituminous coal handled and hopper cars owned by major coal carriers, 1973

Railroad	Originated	Other	Total[1]	Open-top hopper cars owned
1. Penn Central	39,486	39,561	79,047	58,581
2. Norfolk and Western	67,609	9,081	76,690	63,351
3. Chesapeake and Ohio	49,605	10,582	60,187	47,626
4. Louisville and Nashville	48,692	2,356	51,048	35,343
5. Baltimore and Ohio	26,677	13,777	40,454	26,197
6. Southern	23,860	10,818	34,678	12,543
7. Illinois Central Gulf	27,074	1,816	28,890	12,674
8. Burlington Northern	24,711	2,023	26,734	18,846
9. Seaboard Coast Line	-	15,826	15,826	8,980
10. Carolina, Clinchfield and Ohio	7,236	5,893	13,129	4,486
11. Chicago and North Western	4,123	8,344	12,467	4,238
12. Reading	2,221	9,037	11,258	5,188
13. Union Pacific	7,491	3,013	10,504	8,790
14. Western Maryland	4,814	5,204	10,018	5,623
15. Denver and Rio Grande Western	7,850	2,136	9,986	2,479
Total	341,449	139,467	480,916	314,945

[1] The total tonnage for each railroad includes originating and other (connecting and terminating) tonnages. In most cases, portions of tonnage shown for one road will be included in one or more other roads.

Source: Association of American Railroads (2).

Table 4 illustrates the regional distribution of coal handled in 1973. In each district, over half the originating tonnage terminated was not interlined (moved by more than one rail carrier). Generally, coal is moved and cars recycled more efficiently where the origin-destination is with one carrier. Problems encountered with carrier coordination, car control, and interlining tend to limit the market for unit trains.[7] Therefore, unit train movements generally occur as single-line operations (28, p. 243).

TABLE 4. - Bituminous coal handled by district railroads, 1973

(Thousand net tons)

District	Originating and terminating on line	Delivered to connections	Total originating	Total carried[1]
Eastern................	112,986	95,220	208,205	333,334
Southern...............	61,391	45,472	106,863	145,071
Western................	35,795	25,214	61,010	88,022
Total United States	210,172	165,906	376,078	566,427

[1] Includes duplications.

Source: Association of American Railroads (2).

Financial Considerations

Much has been written concerning the financial ills of the railroad industry. A ranking of industrial groups by rate of return on net worth for 1972 places class I railroads 69th at 3.0 percent.[8]

Table 5 lists the capital expenditures for equipment and roadways for the 1963-73 period. Expenditures for equipment peaked in 1966 at $1.5 billion; 1973 aggregate equipment expenditures were $0.9 billion (current dollars). New and rebuilt railroad equipment for class I railroads (table 6) also peaked in 1966 and has since declined 44 percent to 60,390 in 1973. Railroads may require financial assistance for improving mainline trackage and signaling systems, and expanding equipment to meet the growth in capacity required for projected coal haulage (26, p. 40).

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[7] A railroad tends to strive for self-sufficiency because it is most vulnerable when dependent on competing railroads. On interlined shipments, the originating carrier loses some control over the quality of service the shipper receives. This situation attenuates the sense of responsibility that the originating carrier may feel for prompt, safe delivery.

To accommodate this interline traffic, the railroads must perform as a system. At the same time, because the participants in the interlining of traffic will typically serve some of the same markets as one particular road, the railroads find themselves competing with the very carriers upon whom they depend and with whom they are obliged to cooperate.

Demurrage charges are generally regarded as inadequate to optimize freight-car utilization. Individual carriers tend to minimize costs to themselves with only slight regard to any higher costs imposed on connecting carriers. "Foreign" cars are utilized and cared for so as to minimize costs for the railroads whose lines they are on, which may contrast to the interests of the cars' owners.

[8] First National City Bank of New York, Monthly Letter, April 1973.

TABLE 5. - Capital expenditures, class I railroads

(Thousand current dollars)

Year	Total	Equipment	Roadways and structures
1963..................	1,043,788	784,874	258,914
1964..................	1,417,263	1,139,683	277,580
1965..................	1,630,687	1,303,602	327,084
1966..................	1,952,805	1,554,223	398,581
1967..................	1,522,478	1,148,381	374,097
1968..................	1,186,979	818,720	368,259
1969..................	1,509,394	1,088,712	420,681
1970..................	1,351,439	993,095	358,344
1971..................	1,177,627	863,517	314,110
1972..................	1,215,581	847,623	367,958
1973..................	1,342,138	892,690	449,448

Source: Association of American Railroads (2).

TABLE 6. - New and rebuilt railroad equipment, class I railroads

Year	Locomotive units		Freight cars	
	New	Rebuilt	New	Rebuilt
1963.............................	834	2	44,804	3,295
1964.............................	1,071	-	69,051	13,936
1965.............................	1,387	16	77,707	11,825
1966.............................	1,419	6	89,899	15,954
1967.............................	1,109	-	82,828	17,086
1968.............................	978	4	55,964	12,604
1969.............................	1,158	83	68,717	6,944
1970.............................	1,029	64	65,881	9,255
1971.............................	1,179	108	55,046	5,587
1972.............................	1,377	200	47,322	2,660
1973.............................	1,178	188	57,888	1,136

Source: Association of American Railroads (2).

Regulation

The railroads are regulated primarily by the Interstate Commerce Commission (ICC). Regulation has hindered transportation modernization in an era of changing transportation markets.[9] Regulatory practices have caused inefficiency and idle resources in the railroads as well as in all transportation sectors. Costs from these regulatory practices have been estimated at $4 to $10 billion per year to shippers and consumers (28, p. 197).

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[9] For a complete discussion of arguments for regulatory modernization, see chapter VI, pp. 187-209, of Improving Railroad Productivity (28).

Water Transportation

In 1973, coal shipped on the inland waterways--Mississippi and Gulf Intracoastal Waterway (GIWW) River System--accounted for over 69 percent of the coal shipped by water; shipments on the Great Lakes and tidewater constituted the remaining 26 percent and 5 percent, respectively.

Mississippi River System and Gulf Intracoastal Waterway Transportation

Nearly 18 percent of total U.S. shipments was moved on the Mississippi River System and Gulf Intracoastal Waterway (GIWW) in 1973. This modal share has been fairly steady in the last 10 years. Total tonnage moved by barge has increased 36 percent since 1962, keeping pace with the almost 39 percent growth in total coal shipments (fig. 1). Figure 4 illustrates the location of Mississippi River Systems and Gulf Intracoastal Waterway, and the 10 major coal hauling rivers or river sections within the system. The 10 sections were selected to facilitate analysis of current coal movements and for later growth projections.

Coal Markets Served

Primary rivers used in the Mississippi River System for coal transportation are the Monongahela, Green, Kanawha, Ohio, Tennessee, Illinois, and Mississippi Rivers. A minimum 9-foot operating depth is maintained for 15,675 miles of channels. Except for the Lower Mississippi, the channels are slackwater routes that have been improved for navigation by the construction of systems of locks and dams. The Mississippi is open river for 1,000 miles south of St. Louis. Figure 5 illustrates the major coal origin-destination groupings and tonnages by river for 1972 (45). The Ohio River, the primary origin, carried over 32 million tons, nearly 29 percent of all-river shipments of coal in 1972. The Monongahela River originated 27 million tons; Green River, 16 million tons; upper Mississippi, 15 million; Tennessee River, 8 million; and the Kanawha River, 7 million tons.

Figure 6 illustrates the destination shares for coal originating on the Ohio River System. The system, which includes the Ohio, Green, Allegheny, Kanawha, and Monongahela Rivers, originated 57 million tons in 1972 or three-quarters of the total water shipments. Most of the shipment destinations are on the Ohio River.

Types of Carriers

In 1970, 922 carriers operated on inland waterways (60).[10] The carriers' status under ICC economic regulation is commonly used to classify types of barge carriers; that is, carriers may be regulated or unregulated. Unregulated carriers include (1) private operators who carry their own property and

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[10] A 1970 survey of water carriers hauling dry bulk commodities on the Mississippi River System (excluding sand, gravel, crushed rock, and marine shells) identified 73 unregulated carriers.

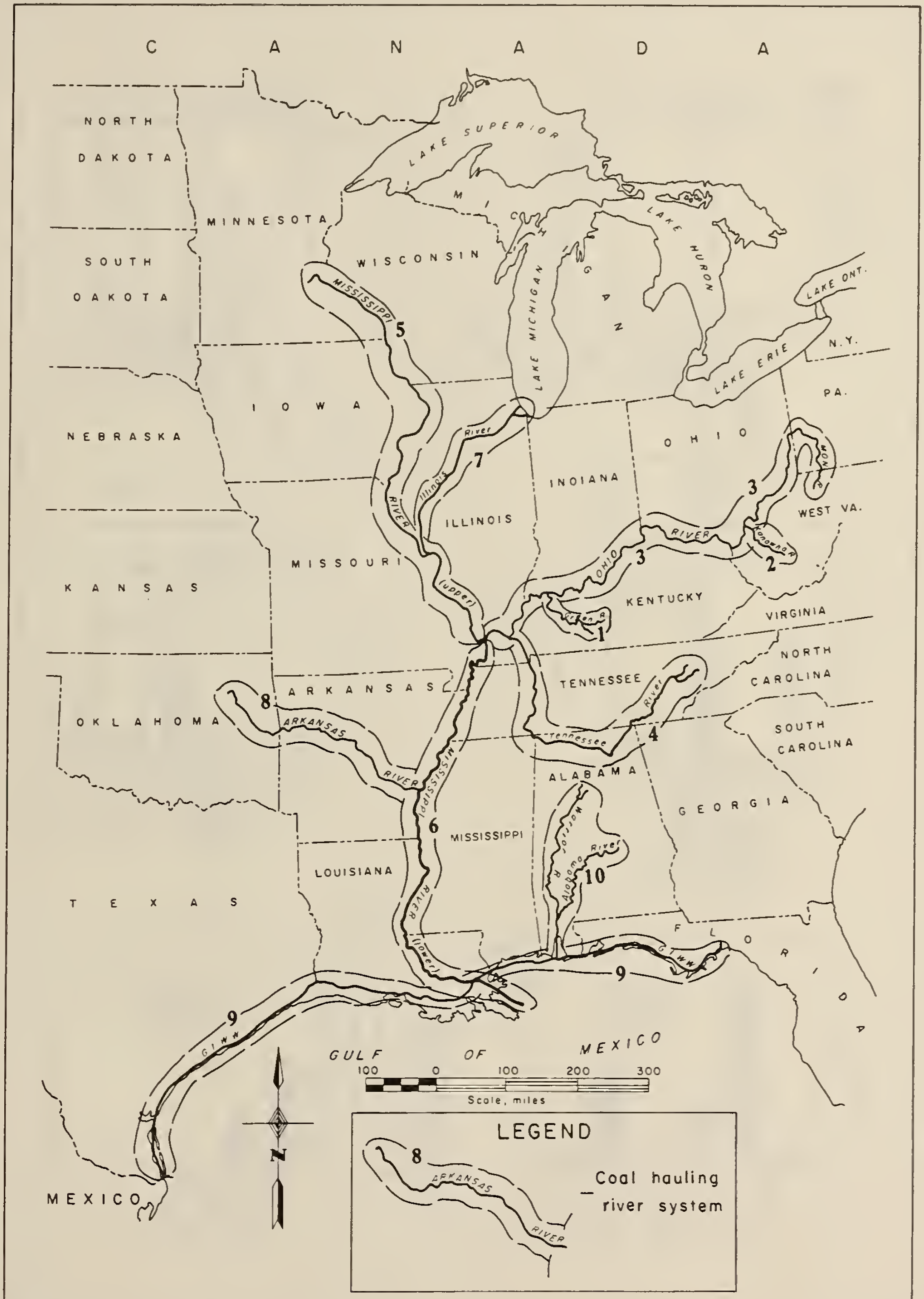

FIGURE 4. - Major coal hauling river systems in the United States.

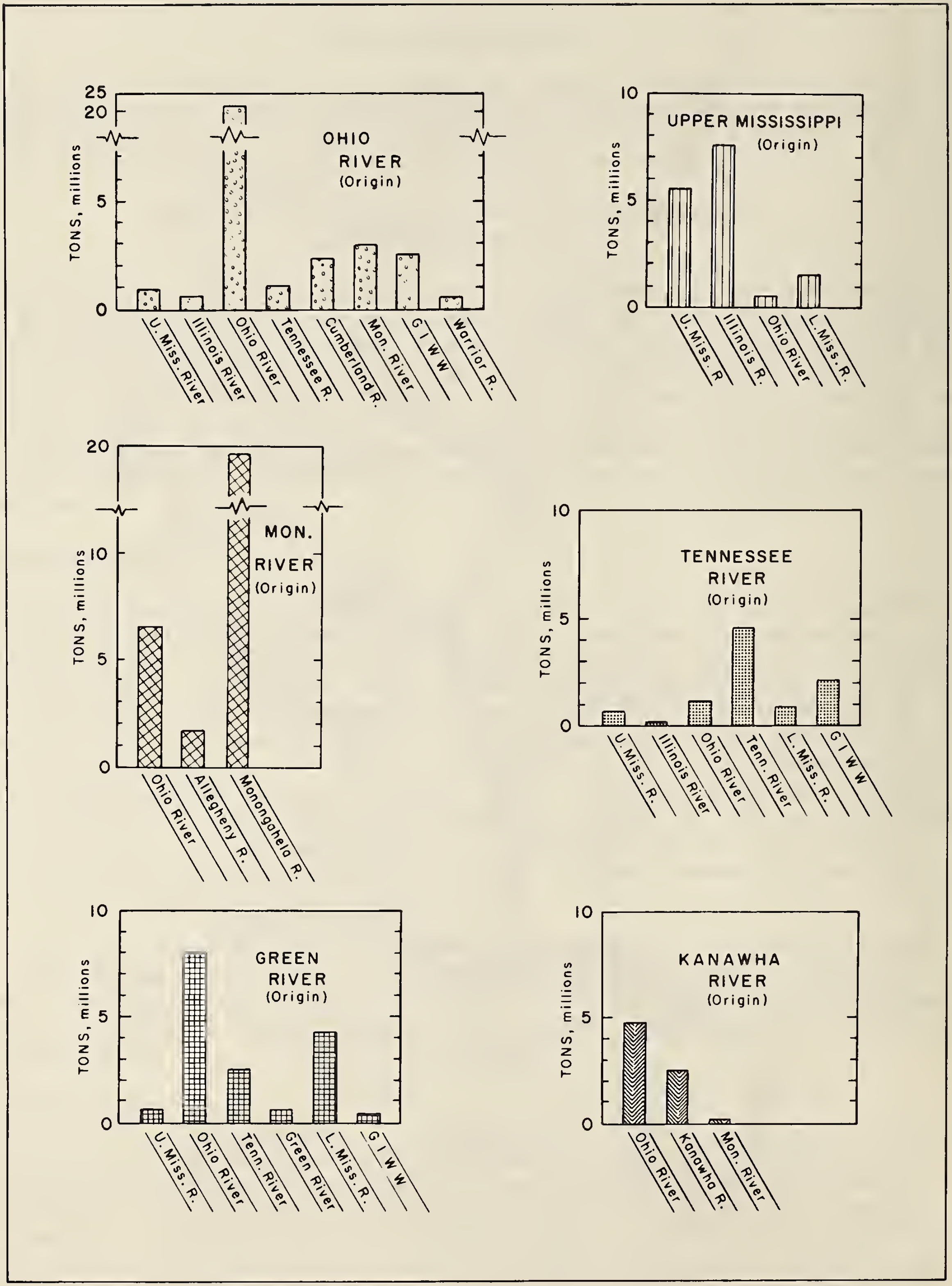

FIGURE 5. - Inland waterway destinations by origin river, 1972.

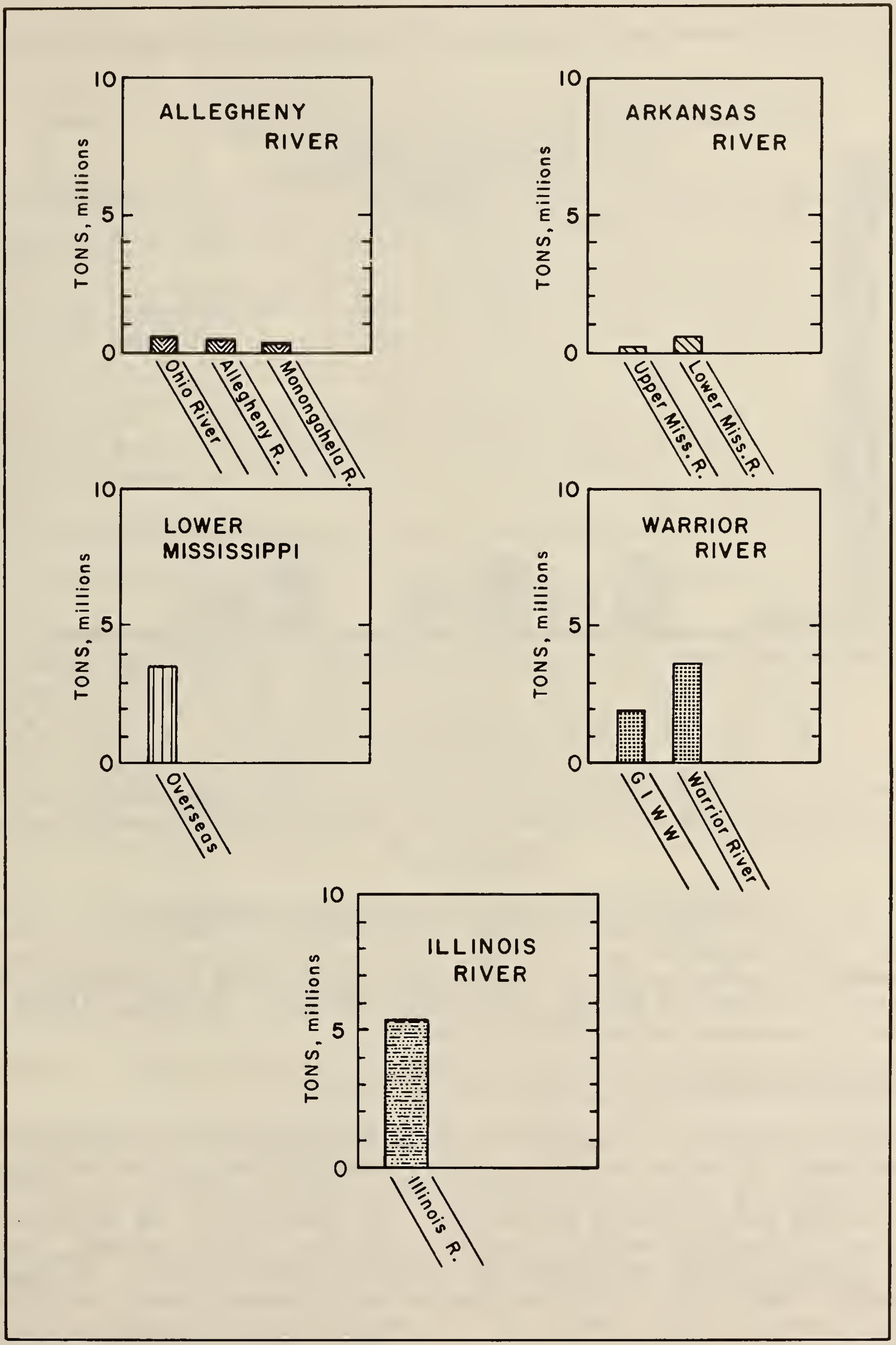

FIGURE 5. - Inland waterway destinations by origin river, 1972 (Con.).

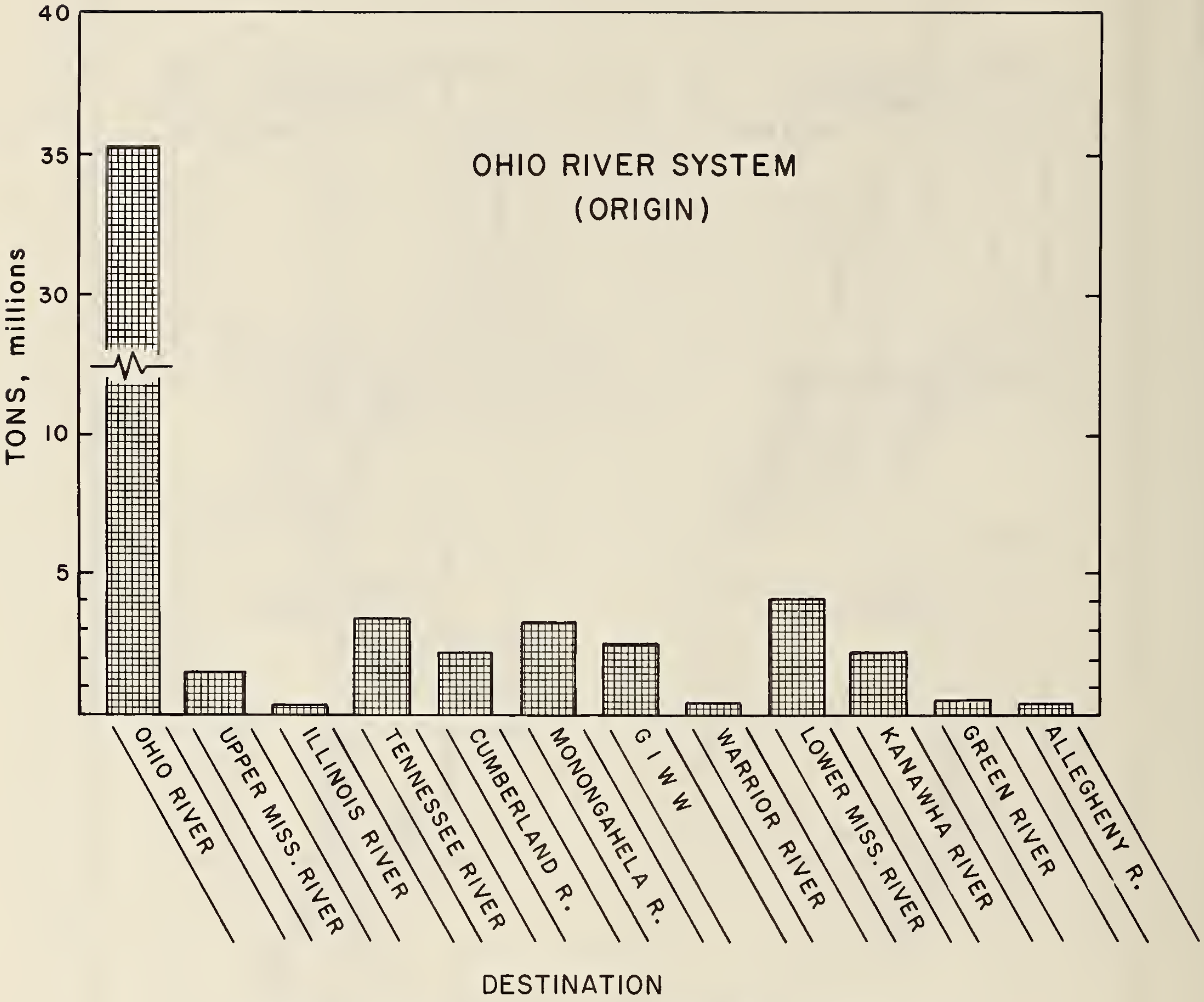

FIGURE 6. - Destinations with Ohio River System origin.

(2) exempt, for-hire operators who transport commodities not regulated by ICC. Most coal is shipped by exempt, unregulated carriers. Therefore little coal traffic is regulated and reported to the ICC.

Methods of Operation

A tow is formed by tying barges and towboat together so that they act as a single unit. With the towboat providing power at the rear of the barges, a greater number of barges can be handled, at greater speeds and under better control, than in pull-towing operations. The character of the waterways determine the maximum size and speed of tows. The width of channel, bends and curves, size of locks, etc., serve to limit speed and tow size. The small restricted rivers, such as the Monongahela and Allegheny Rivers, are limited to 4 to 6 standard barges (900 tons, 175 feet by 26 feet), while on the open lower Mississippi, maximum tow size is 40 jumbo barges (1,400 tons, 195 feet by 35 feet). Speeds range from 90 to 200 miles per day. The dry cargo barge fleet (table 7) numbered 14,000 in 1972 with an average capacity of 1,139 net tons.

TABLE 7. - Inland waterways fleet on the Mississippi River-Gulf Intracoastal System

Equipment	Jan. 1, 1969	Jan. 1, 1970	Jan. 1, 1971	Jan. 1, 1972	Jan. 1, 1973
Dry cargo barges:					
Number..............................	12,056	12,550	13,318	13,985	14,904
Total cargo capacity..million tons..	13.5	14.3	14.9	15.9	17.3
Average net capacity..........tons..	1,121	1,138	1,116	1,139	1,160
Towboats:					
Number..............................	2,214	2,297	2,344	2,427	2,293
Total horsepower.........thousands..	2,134	2,275	2,305	2,549	2,654
Average horsepower per towboat......	964	990	983	1,050	1,157
Ratio: Dry barge/towboats...........	5.4	5.5	5.7	5.8	6.5

Source: Transportation Series 5, U.S. Army Corps of Engineers.

The average length of haul for coal and coke by exempt, for-hire carriers was 341 miles in 1972 (45), somewhat less than the all-commodity average of 379 miles.

Great Lakes and Tidewater

Total tonnage and relative importance for both water modes have declined in the last decade. Eight percent and one percent of total coal shipments were moved on the Great Lakes and by tidewater in 1973, respectively.

Great Lakes shipments of coal in 1973 were primarily originated at Lake Erie ports for movement to United States and Canadian ports (table 8). An additional 5.4 million short tons were loaded on Lake Michigan ports. The Bureau of Mines reported 7,355,000 short tons of coal moved by tidewater in 1973; Hampton Roads, Va., was the primary shipping area.

TABLE 8. - Coal shipments to Canada and United States from Lake Erie ports, 1973, thousand net tons

Country	Superior	Sault Ste. Marie	Huron	Lower rivers	Erie	Through Welland Canal	Lake Michigan
Canada.........	236	2,400	69	3,184	1,652	8,245	-
United States..	2,805	259	812	11,992	323	-	2,118
Total.....	3,041	2,659	881	15,176	1,975	8,245	2,118

Source: Lake Carriers Association.

Markets for Great Lakes and tidewater coal transportation are limited by geographical locations and port facilities. Some growth has been experienced in bimodal (rail-Great Lakes) movements from the West.

Truck Transportation

Over 11.5 percent of total coal shipments in 1973 was by truck, up from 7.9 percent in 1962. Truck transportation dominates the short-haul segment of coal shipping and is the most flexible mode. It services both small consumers and small producers, as well as some large tonnage origin-destinations. Ohio and Pennsylvania received over one-third of the total shipments by truck in 1973 (table 9).

TABLE 9. - Truck shipments of bituminous coal, by State, 1973, thousand net tons

State	Shipments originated	Shipments received
Alabama and Mississippi	3,003	[1]4,847
Alaska	115	(2)
Arkansas, Louisiana, Oklahoma, and Texas	142	244
Colorado	746	1,259
Delaware and Maryland	553	689
Georgia	-	-
Illinois	3,393	[1]5,540
Indiana	3,682	5,847
Iowa	439	459
Kansas	74	-
Kentucky	6,094	9,979
Missouri	90	[1]3,304
Montana and Idaho	28	80
New Mexico	3	7,330
New York	-	1,330
North Carolina	-	14
North and South Dakota	-	[1]2,887
Ohio	11,555	[1]15,836
Pennsylvania	17,824	[1]20,618
Tennessee	2,618	2,376
Utah	1,492	1,355
Virginia	1,285	106
Washington and Oregon	24	30
Wast Virginia	3,776	[1]3,181
Wyoming	45	[1]5,670
Origin-destinations not revealable	-	223
Total United States[3]	57,268	[1]93,004
Total destinations via truck	-	68,114

[1] Includes shipments via tramway, conveyors, and private railroad, as noted.
[2] Included with all rail shipments.
[3] Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines Minerals Yearbook (54).

Alternative Modes

Two alternative modes are used for coal transport where select conditions prevail:

1. Conveyors are used for short hauls (less than 20 miles) where the life and size of the mining operation will support the capital investment. They are often employed for so-called mine-mouth powerplants.

2. Coal-slurry pipelines may be used where high-volume, long-distance transportation is required and the railroad network is such that the origin-destination cannot be efficiently served. Several long-distance pipelines are currently under study to move coal from the West to Midwest and South. Problems of obtaining eminent domain and water rights may impede expansion of coal-slurry pipelines in the next decade.

COMPARATIVE MODAL ADVANTAGES

Selection of transportation modes is primarily made on the basis of cost. However, other factors inherent to each mode influence their selection for a particular origin-destination. Transportation flexibility may be required where the market and/or source is short term. In general, truck is the most flexible coal transport mode followed by rail, barge, conveyor, and slurry pipeline.

Required annual tonnages for an origin-destination may limit the application of some hauling methods; small tonnages, which cannot efficiently utilize dedicated transport equipment (such as unit trains and barges), may be transported by non-unit trains or trucks. Slurry pipelines become more economical (on a ton-mile basis) with increased tonnages--20 to 25 million annual tons is the current estimated maximum capacity.

Distance may limit application of some coal hauling methods. Generally, conveyors best serve rather short distance origin-destinations (under 20 miles), followed by trucks, which efficiently service origin-destinations up to about 50 miles.[11] In contrast, trains and barges may service any distance.

ANALYSIS OF FACTORS DETERMINING TRANSPORTATION EQUIPMENT REQUIREMENTS FOR 1985 COAL PRODUCTION AND CONSUMPTION

In the analysis of equipment requirements for transporting coal in 1985, the major factors to be considered are--

1. Location and interaction of the centers of production and consumption for coal.

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[11] Occasionally where rail service is not available or to cover marginal fuel needs for powerplants, truck haulage is used for distances of 200 miles and more.

2. Comparative modal costs of transporting coal.

3. Existence of constraining factors and their effects on coal haulage capacity.

Each factor is considered in this analysis.

Assumptions to be carried throughout the study include the following:

1. Coal consumption in 1985 will equal the projected production of 1.2 billion tons.

2. Rail facilities will be available for an unlimited amount of coal traffic in 1985.

3. Discussion of both the regional and numerical aspects of the study is extremely aggregate and macro. Numbers should not be treated in the micro without due caution. Figure 7 provides guidance to the reader for the methods of analysis that follows. Each block description is keyed into an analysis subheading.

Selection of Production and Consumption Centers (1)

The national scope of this project dictated that the analysis of the producing and consuming regions of coal be macroeconomic rather than microeconomic. Battelle Columbus Laboratories (5) used this macro approach in studying coal production and consumption centers for the Federal Bureau of Mines. Therefore, an assignment process for selecting representative production and consumption centers was established.

The coal producing districts (as defined by the Federal Bureau of Mines) were selected to represent areas of supply with centrally located cities within these districts depicting the production centers. Table 10 lists the 23 producer districts and their corresponding shipping origins.

TABLE 10. - Coal producing districts and the corresponding shipping origins

Producer district[1]	Shipping origin
1 Eastern Pennsylvania..	Clearfield, Pa.
2 Western Pennsylvania..	Pittsburgh, Pa.
3 Northern West Virginia	Grafton, W. Va.
4 Ohio..................	Urichsville, Ohio.
5 Michigan..............	-
6 Panhandle.............	Weirton, W. Va.
7 Southern Number 1.....	Beckley, W. Va.
8 Southern Number 2.....	Hazard, Ky.
9 West Kentucky.........	Rockport, Ky.
10 Illinois.............	Mt. Vernon, Ill.
11 Indiana..............	Vincennes, Ind.
12 Iowa.................	Des Moines, Iowa.
13 Alabama..............	Birmingham, Ala.
14 Arkansas-Oklahoma.....	Fort Smith, Ark.
15 Southwestern.........	Oklahoma City, Okla.
16 Northern Colorado.....	Denver, Colo.
17 Southern Colorado.....	Grand Junction, Colo.
18 New Mexico...........	Black Mesa, Ariz.
19 Wyoming..............	Casper, Wyo.
20 Utah.................	Spring Canyon, Utah.
21 North Dakota-South Dakota.	Minot, N. Dak.
22 Montana..............	Billings, Mont.
23 Washington...........	Auburn, Wash.

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[1] Coal producing districts as defined by the Federal Bureau of Mines (appendix table B-1).

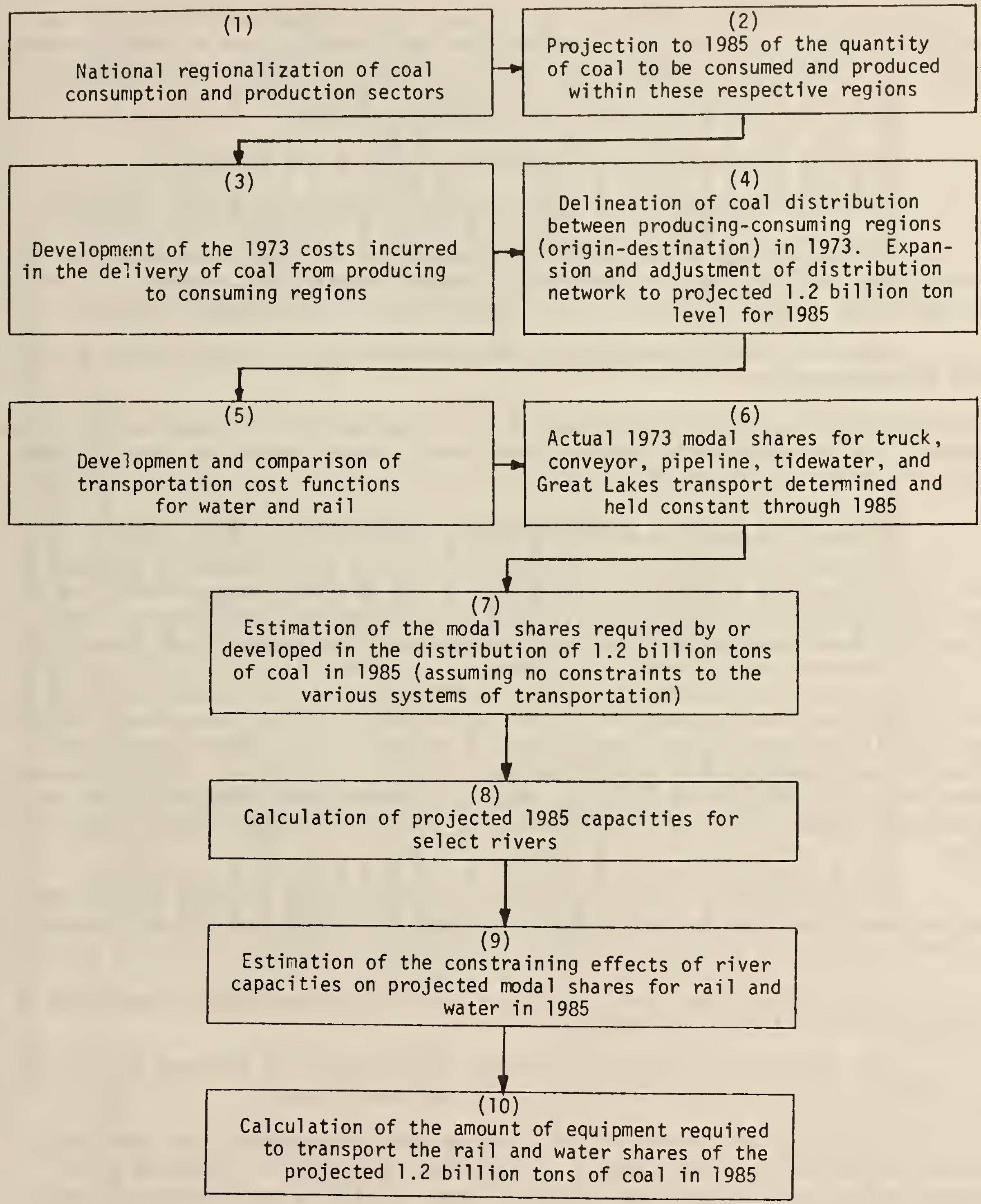
(1)
National regionalization of coal consumption and production sectors
(2)
Projection to 1985 of the quantity of coal to be consumed and produced within these respective regions
(3)
Development of the 1973 costs incurred in the delivery of coal from producing to consuming regions
(4)
Delineation of coal distribution between producing-consuming regions (origin-destination) in 1973. Expansion and adjustment of distribution network to projected 1.2 billion ton level for 1985
(5)
Development and comparison of transportation cost functions for water and rail
(6)
Actual 1973 modal shares for truck, conveyor, pipeline, tidewater, and Great Lakes transport determined and held constant through 1985
(7)
Estimation of the modal shares required by or developed in the distribution of 1.2 billion tons of coal in 1985 (assuming no constraints to the various systems of transportation)
(8)
Calculation of projected 1985 capacities for select rivers
(9)
Estimation of the constraining effects of river capacities on projected modal shares for rail and water in 1985
(10)
Calculation of the amount of equipment required to transport the rail and water shares of the projected 1.2 billion tons of coal in 1985

FIGURE 7. - Analysis flow chart for transportation equipment.

The Bureau of Mines method of reporting coal consumption statistics by State provided the foundation for using the individual States as the consuming regions. Centers of consumption for these States were selected as follows:

1. All States have at least one consumption center.

2. Adequate transportation facilities exist at the centers.

3. The centers represent a major area of consumption within the State.

4. A State having a navigable waterway either forming a boundary or transversing its area has (1) its demand center located for reception of both rail and water transportation or (2) separate rail/water demand centers.

5. Larger consuming States have multiple centers to avoid possible distance discrimination.

Export coal was handled on the basis of the location of the final market to be reached. The 47 consumption regions and their corresponding centers of consumption are presented in table 11.

Projections of Coal Production and Consumption by Region (2)

The allotment of district production necessary to produce 1.2 billion tons of coal in 1985 was taken directly from the Project Independence Blueprint intermediate scenario (16)--table 8A (see appendix table C-1). These projections were made by the Project Independence Interagency Task Force.

The regional configuration for the consumption of 1.2 billion tons of coal in 1985 was based primarily on the publication titled "Assessment of the Impact of Air Quality Requirements on Coal in 1975, 1977, 1980" (55), which projected coal consumption to 1980 in the utility, industrial, and residential/commercial sectors (excludes coking coals). Because this transportation study was focused primarily on 1985, the previous projections were adjusted by five steps:

1. Projections for export and domestic coking coal consumption to 1985 were obtained from the Bureau of Mines unpublished estimates. These values were then subtracted from the 1.2 billion tons of coal to be produced in 1985.

2. The resultant was divided by the total projected 1980 consumption in order to obtain a factor of increase.

3. The individual sectors comprising the consumption pattern were then multiplied by this factor of increase on a regional basis.

4. The projected value for 1985 coking coal consumption was then redistributed according to each State's contribution to total 1973 coking coal consumption as reported in the Bureau of Mines publication "Bituminous Coal and Lignite Distribution--Calendar Year 1973" (56).

5. Export markets were established as individual regions of consumption. Resultant regional consumption is depicted in table 12 (see appendix A).

TABLE 11. - Projected coal consuming regions and the corresponding centers of consumption

Consumer region	Consumption centers
Alabama	Birmingham, Ala.
Arizona	Phoenix, Ariz.
Arkansas	Little Rock, Ark.
Colorado	Denver, Colo.
Delaware	Philadelphia, Pa.
District of Columbia	Baltimore, Md.
Florida	Tampa, Fla.
Georgia	Atlanta, Ga.
Idaho	Boise, Idaho.
Illinois	Chicago, Ill. Peoria, Ill.
Indiana	Indianapolis, Ind. Madison, Ind.
Iowa	Des Moines, Iowa. Dubuque, Iowa.
Kansas	Wichita, Kans.
Kentucky	Louisville, Ky.
Louisiana	New Orleans, La.
Maryland	Baltimore, Md.
Massachusetts	Boston, Mass.
Michigan	Detroit, Mich.
Minnesota	St. Paul, Minn.
Mississippi	Yazoo City, Miss.
Missouri	St. Louis, Mo. Kansas City, Mo.
Montana	Billings, Mont.
Nebraska	Lincoln, Nebr.
Nevada	Carson City, Nev.
New Hampshire	Portsmouth, N.H.
New Jersey	Philadelphia, Pa.
New Mexico	Albuquerque, N. Mex.
New York	New York, N.Y. Buffalo, N.Y.
North Carolina	Raleigh, N.C.
North Dakota	Minot, N. Dak.
Ohio	Cleveland, Ohio. Cincinnati, Ohio.
Oklahoma	Oklahoma City, Okla. Muskogee, Okla.
Oregon	Portland, Oreg.
Pennsylvania	Pittsburgh, Pa. Philadelphia, Pa.
South Carolina	Columbia, S.C. Charleston, S.C.
South Dakota	Rapid City, S. Dak.
Tennessee	Nashville, Tenn. Johnsonville, Tenn.
Texas	Fort Worth, Tex. Houston, Tex. El Paso, Tex.
Utah	Salt Lake City, Utah
Virginia	Hampton Roads, Va.
Washington	Spokane, Wash.
West Virginia	Charleston, W. Va.
Wisconsin	Green Bay, Wis. La Crosse, Wis.
Wyoming	Cheyenne, Wyo.
Canada	Cleveland, Ohio.
Mexico	El Paso, Tex.
Other export	Hampton Roads, Va.

TABLE 12. - Projected regional consumption of coal, 1985

(Thousand short tons)

Region	Projected 1980 consumption[1]	Weighted unidentified 1980 consumption[1]	Projected 1985 coking coal consumption[2]	Projected 1985 consumption
Alabama	25,525	1,100	8,547	48,752
Arizona	8,525	728	0	13,973
Arkansas	5,685	39	137	8,780
Colorado	12,025	943	1,427	21,010
Delaware	1,292	52	775	2,805
District of Columbia	862	8	0	1,314
Florida	7,105	337	0	11,240
Georgia	18,735	889	0	29,633
Idaho	500	0	0	755
Illinois	47,310	270	3,803	75,652
Indiana	45,055	256	17,431	85,854
Iowa	10,435	62	0	15,851
Kansas	7,330	50	0	11,144
Kentucky	30,960	1,351	1,489	50,279
Louisiana	1,485	10	36	2,293
Maryland	9,070	416	5,323	19,649
Massachusetts	75	0	0	113
Michigan	36,440	175	6,247	61,539
Minnesota	11,910	71	1,386	19,477
Mississippi	1,660	80	556	3,183
Missouri	22,285	142	409	34,276
Montana	6,645	534	0	10,841
Nebraska	7,610	50	0	11,576
Nevada	7,380	636	0	12,105
New Hampshire	1,120	54	0	1,774
New Jersey	1,165	53	0	1,840
New Mexico	9,495	826	0	15,585
New York	8,910	291	5,276	19,171
North Carolina	28,660	1,281	0	45,213
North Dakota	1,770	776	0	3,845
Ohio	70,348	374	17,181	123,975
Oklahoma	6,640	46	159	10,255
Oregon	70	0	0	106
Pennsylvania	46,710	1,920	29,695	103,128
South Carolina	8,150	314	0	12,781
South Dakota	9,205	121	0	10,483
Tennessee	23,485	997	247	37,217
Texas	37,020	257	889	57,178
Utah	4,910	349	2,324	10,266
Virginia	7,835	245	0	12,202
Washington	2,385	190	0	3,887
West Virginia	31,850	1,287	6,657	56,696
Wisconsin	17,415	92	306	26,742
Wyoming	9,325	790	0	15,274
Canada	(3)	(3)	(3)	[2]23,184
Mexico	(3)	(3)	(3)	[2]441
Other export	(3)	(3)	(3)	[2]51,375
Total	-	-	-	1,198,312

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[1] Based on "Assessment of the Impact of Air Quality Requirements on Coal in 1975, 1977, and 1980" (55).

[2] Based on Federal Bureau of Mines projections (unpublished).

[3] Not calculated.

Delivered Cost of Coal for the Origin-Destination Matrix (3)

The regional consumption pattern having been established, a method for deriving the overall production-consumption (or origin-destination) matrix was developed. This required the identification of the existing delivered cost of coal from producing districts to consuming regions.

A similar method of analysis utilizing the delivered cost of coal was employed in the Bureau of Mines publication IC 8614 (25) and was consequently adopted for use in this study. The 1973 delivered cost of coal matrix was developed by using--

1. 1973 values for cost of coal per ton and Btu content of coal per ton.

2. Information on 1973 rail costing practices.[12]

3. The IC 8614 formula for cost of coal in cents per million Btu (see appendix B).

4. An assemblage of the mileage differentials between the origin-destination pairings in question.

Table 13 represents an aggregation of mileage differentials between each individual consuming sector and the producer districts.[13] These distances are calculated on a center city of production to a center city of consumption basis. The resultant application of all available data to the cost of coal function is presented in the delivered cost of coal matrix, table 14.

Projected Distribution of Bituminous Coal by Origin-Destination (4)

A discrimination method was developed to derive the projected 1985 supply matrix between districts of production and States of consumption. This method was based on historical consumption patterns with least cost analysis introduced as a refinement.

The 1973 bituminous coal and lignite distribution (56) was used for historical data. It lists consumption by State (destination) and the various districts of supply (origins) for these destinations. This information was used to develop a preliminary origin-destination matrix for year 1985 as follows:

1. The 1973 distribution of coal as presented in Bituminous Coal and Lignite Distribution, Calendar Year 1973, is held constant for 1985. This treatment is justified because (1) the distribution data represent the latest available source and (2) historic trends and tendencies will be continued through 1985.

2. The individual State's projected 1985 consumption, as developed previously, is divided by its historic 1973 consumption to obtain a factor of increase indigenous only to that State.

3. Each producer district's contribution to the State's 1973 consumption is multiplied by the factor of increase to obtain a preliminary 1985 supply contribution.

4. The process is repeated for each of the coal consuming States.

5. The export markets are increased utilizing the projected Bureau of Mines 1985 export figures. The 1973 origins of supply to these markets is held constant through 1985.

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[12] Based on the assumption that rail transportation is always available.

[13] No production in district 5.

TABLE 13. - Rail distance matrix, miles

Destination	Origin - Coal producing districts 1/																					
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Albuquerque, New Mex	1,908	1,776	1,827	1,744	1,733	1,814	1,763	1,377	1,269	1,340	1,108	1,388	859	648	477	775	444	802	977	1,921	1,133	2,053
Atlanta, Ga	970	806	789	697	806	798	502	398	624	498	952	167	716	907	1,526	1,801	1,754	1,835	2,001	1,665	1,921	1,392
Baltimore, Md	365	328	286	415	371	295	812	837	841	826	1,154	799	1,665	1,454	1,822	2,120	2,546	2,010	2,322	1,668	2,085	2,959
Billings, Mont	1,879	1,747	1,858	1,775	1,704	1,845	1,794	1,524	1,389	1,525	1,041	1,788	1,605	1,394	656	954	1,577	331	623	788	0	925
Birmingham, Ala	929	797	780	697	754	792	620	302	473	402	819	0	529	740	1,373	1,671	1,832	1,618	1,873	1,522	1,788	2,713
Boise, Idaho	2,383	2,251	2,345	2,262	2,207	2,332	2,281	1,922	1,849	1,878	1,439	2,186	1,843	1,632	893	701	1,786	1,008	528	1,352	564	674
Boston, Mass	632	668	695	760	710	793	1,149	1,248	1,123	1,174	1,376	1,215	1,619	1,743	2,044	2,349	2,556	2,315	2,549	1,950	2,296	3,181
Buffalo, N.Y	314	260	449	347	303	699	674	699	629	688	882	925	1,460	1,249	1,550	1,848	2,306	1,738	2,050	1,395	1,802	2,687
Carson City, Nev	2,614	2,482	2,588	2,505	2,488	2,557	2,524	2,399	2,020	2,101	1,715	2,450	2,002	1,791	1,037	877	1,110	887	694	1,956	972	1,133
Charleston, S.C	843	901	764	931	901	778	730	735	860	840	1,302	549	1,500	1,289	1,876	2,174	2,374	2,101	2,247	1,875	2,271	3,196
Charleston, W.Va	464	332	190	266	281	82	295	449	470	505	851	871	994	1,084	1,456	1,731	2,128	1,684	1,859	1,356	1,763	2,648
Cheyenne, Wyo	1,595	1,463	1,558	1,475	1,420	1,545	1,494	1,135	1,000	1,091	652	1,399	1,056	845	106	404	1,025	219	606	1,341	550	1,470
Chicago, Ill	632	468	570	392	500	589	500	356	358	250	358	651	701	794	1,026	1,331	1,538	1,300	1,531	930	1,278	2,163
Cincinnati, Ohio	448	316	297	217	276	295	220	264	184	190	639	481	756	880	1,252	1,577	1,847	1,480	1,578	1,141	1,559	2,112
Cleveland, Ohio	263	131	295	97	88	424	337	515	493	384	698	741	976	1,065	1,366	1,664	2,122	1,554	1,866	1,211	1,618	2,503
Columbia, S.C	803	772	728	802	772	649	601	606	731	711	1,173	420	1,371	1,160	1,747	2,045	2,245	1,972	1,954	1,746	2,142	3,067
Denver, Colo	1,658	1,494	1,541	1,402	1,462	1,560	1,471	1,152	993	1,068	683	1,373	962	739	0	298	677	410	475	1,197	656	1,575
Des Moines, Iowa	958	826	938	855	783	925	874	554	418	484	0	819	333	565	683	958	1,562	873	1,048	734	1,041	1,966
Detroit, Mich	428	296	459	278	253	477	481	513	573	382	630	739	973	1,031	1,298	1,595	2,055	1,488	1,797	1,143	1,550	2,435
Dubuque, Iowa	786	654	733	567	610	844	703	522	313	409	198	838	803	797	884	1,159	1,763	1,074	1,249	727	1,134	2,019
El Paso, Tex	1,966	1,834	1,860	1,777	1,791	1,847	1,796	1,370	1,345	1,373	1,166	1,304	929	718	730	1,028	694	1,055	1,230	2,174	1,386	2,206
Fort Worth, Tex	1,455	1,323	1,306	1,297	1,280	1,293	1,089	804	822	915	714	689	258	205	803	1,078	1,087	1,130	1,188	1,458	1,459	2,384
Green Bay, Wis	814	682	767	589	697	786	697	553	555	447	447	848	911	991	1,130	1,405	1,951	1,351	1,495	797	1,205	2,090
Hampton Roads, Va	553	522	474	603	559	396	766	791	783	983	1,329	794	1,254	1,445	1,888	2,217	2,489	2,170	2,345	1,842	2,249	3,134
Houston, Tex	1,558	1,426	1,409	1,326	1,383	1,396	1,345	858	1,000	866	1,002	718	519	500	1,099	1,397	1,369	1,424	1,599	1,736	1,755	2,678
Indianapolis, Ind	503	371	409	325	328	396	346	252	209	127	542	503	693	782	1,154	1,452	1,874	1,380	1,654	1,055	1,462	2,347
Johnsonville, Tenn	886	754	734	654	723	669	519	161	171	212	588	245	391	581	1,215	1,490	1,625	1,647	1,705	1,459	1,558	2,483
Kansas City, Mo	1,053	889	905	797	857	924	835	516	362	432	221	737	379	343	636	941	1,087	1,030	1,141	1,015	1,051	1,976
LaCrosse, Wis	903	771	850	684	727	961	820	639	430	526	265	955	920	914	904	1,226	1,830	1,141	1,316	608	1,015	1,900
Lincoln, Nebr	1,148	1,016	1,128	1,045	973	1,115	1,064	744	547	674	190	991	994	633	483	758	1,356	673	930	878	841	1,766
Little Rock, Ark	1,074	942	925	852	899	912	740	388	400	499	497	385	156	164	1,039	1,314	1,398	1,420	1,478	1,398	1,748	2,669
Louisville, Ky	562	430	594	330	387	400	228	141	185	130	614	392	640	867	1,188	1,486	1,907	1,413	1,688	1,166	1,583	2,508
Madison, Ind	545	413	394	314	374	392	297	198	146	151	629	470	707	831	1,203	1,528	1,798	1,431	1,529	1,092	1,510	2,063
Minot, N. Dak	1,461	1,329	1,443	1,357	1,286	1,427	1,376	1,196	1,284	1,025	723	1,283	1,334	1,299	1,109	1,384	1,982	781	1,580	0	788	1,229
Muskogee, Okla	1,168	1,036	1,061	1,098	1,040	1,074	947	651	501	580	566	725	78	170	856	856	1,209	1,081	1,356	1,161	1,411	2,432
Nashville, Tenn	749	617	600	517	574	586	415	97	246	187	664	205	515	726	1,238	1,536	1,818	1,464	1,738	1,317	1,634	2,559
New Orleans, La	1,590	1,152	1,135	1,317	1,426	1,418	1,277	863	794	1,110	1,039	355	535	742	1,341	1,039	1,429	1,750	1,239	1,810	1,924	2,677
New York, N.Y	403	439	466	531	481	564	920	1,185	972	945	1,266	986	1,468	1,592	1,934	2,239	2,416	2,205	2,439	1,840	2,186	2,846
Oklahoma City, Okla	1,285	1,153	1,179	1,096	1,110	1,166	1,115	729	621	737	565	740	211	0	739	1,037	1,092	1,064	1,239	1,049	1,394	2,315
Peoria, Ill	744	612	529	530	533	629	551	297	190	212	337	614	597	664	1,020	1,295	1,708	1,210	1,385	1,071	1,378	2,303
Philadelphia, Pa	199	348	381	526	391	390	894	919	880	908	1,174	894	1,712	1,501	1,842	2,140	2,568	2,030	2,342	1,823	2,094	2,979
Phoenix, Ariz	2,484	2,352	2,349	2,266	2,255	2,336	2,285	1,899	1,834	1,862	1,630	1,902	1,381	1,170	1,026	1,301	260	1,354	1,125	2,135	1,682	1,708
Pittsburgh, Pa	132	0	164	87	43	414	546	571	532	560	826	797	1,364	1,153	1,494	1,792	2,220	1,682	1,994	1,340	1,747	2,632
Portland, Oreg	2,800	2,668	2,769	2,686	2,625	2,756	2,705	2,401	2,266	2,402	1,918	2,665	2,342	2,131	1,372	1,217	1,618	1,670	1,008	1,376	593	161
Portsmouth, N.H	663	695	725	790	740	823	1,179	1,278	1,170	1,204	1,406	1,245	1,649	1,773	2,074	2,379	2,586	2,345	2,579	1,980	2,326	3,211
Raleigh, N.C	604	573	525	654	610	447	817	842	843	1,034	1,380	582	1,298	1,322	1,876	2,216	2,365	2,194	2,396	1,893	2,300	3,185
Rapid City, S. Dak	1,502	1,370	1,480	1,302	1,410	1,499	1,410	1,230	1,151	1,103	619	1,418	1,150	1,104	580	855	1,453	332	1,027	601	797	1,722
Spokane, Wash	2,432	2,300	2,411	2,328	2,257	2,398	2,347	2,117	1,982	2,118	1,634	2,381	2,198	1,987	1,249	1,123	1,986	1,547	914	1,008	961	332
Salt Lake City, Utah	2,114	1,982	2,077	1,994	1,939	2,064	2,013	1,782	1,519	1,590	1,171	1,906	1,458	1,237	570	333	963	738	124	1,457	1,310	1,088
St. Louis, Mo	743	611	637	554	568	624	573	214	79	144	340	479	453	542	914	1,212	1,634	1,140	1,414	1,211	1,310	2,235
St. Paul, Minn	1,097	865	976	893	822	963	912	732	654	561	259	1,047	1,300	824	886	1,184	1,807	1,074	1,386	475	882	1,767
Tampa, Fla	1,394	1,262	1,214	1,293	1,263	1,140	1,463	959	1,121	1,059	1,467	648	1,197	1,388	2,021	2,296	2,425	2,308	2,431	2,164	2,436	3,361
Wichita, Kans	1,224	1,092	1,118	1,035	1,049	1,105	1,054	808	561	625	433	819	298	172	580	878	1,165	905	1,080	1,167	1,236	2,161
Yazoo City, Miss	1,107	975	906	875	956	1,254	964	764	480	532	810	294	351	541	1,052	1,052	1,528	1,618	1,618	1,519	1,900	2,825

1/ Coal producing districts as defined by Federal Bureau of Mines.

TABLE 14. - Delivered cost of coal, cents per million Btu, 1973 dollars

Destination	Origin - Coal producing districts 1/																					
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Albuquerque, N. Mex	69	76	67	66	69	88	69	54	60	58	59	68	77	35	48	54	28	42	67	85	45	85
Atlanta, Ga	55	62	52	49	55	74	51	38	49	43	56	52	75	39	70	71	50	61	83	77	60	72
Baltimore, Md	46	55	48	45	48	71	56	45	53	49	60	60	90	48	76	77	63	64	88	78	63	103
Billings, Mont	68	76	68	67	69	89	70	57	62	61	58	74	89	47	51	57	47	34	62	52	19	63
Birmingham, Ala	55	62	52	49	54	74	53	37	46	42	54	45	72	37	66	69	51	57	81	73	58	98
Boise, Idaho	76	83	75	75	77	96	77	63	70	67	66	80	93	51	56	53	50	46	60	68	34	58
Boston, Mass	50	60	51	50	53	74	61	52	57	55	65	66	89	52	81	81	63	70	92	86	67	107
Buffalo, N.Y	46	57	47	44	47	73	54	43	49	47	55	62	87	45	70	72	59	59	84	70	58	98
Carson City, Nev	79	87	79	79	81	99	81	71	73	71	72	84	95	53	59	56	39	44	63	86	42	67
Charleston, S.C	53	63	52	53	56	74	55	44	53	49	63	56	87	45	77	78	60	66	87	84	67	108
Charleston, W. Va	48	55	45	46	50	63	52	39	46	43	54	61	79	42	68	70	56	58	81	69	57	97
Cheyenne, Wyo	64	72	63	62	64	85	66	50	55	54	50	69	80	38	40	48	38	35	62	68	34	74
Chicago, Ill	50	57	49	44	50	71	51	38	44	43	44	58	74	38	59	64	46	51	76	56	48	87
Cincinnati, Ohio	48	55	49	44	50	71	50	40	43	40	50	55	75	39	64	68	51	55	77	62	53	86
Cleveland, Ohio	48	53	49	39	43	69	49	40	46	41	51	59	79	42	66	69	56	56	81	64	54	94
Columbia, S.C	53	62	51	51	54	72	53	42	51	47	61	54	85	43	74	75	58	64	83	80	64	105
Denver, Colo	65	72	63	61	65	85	65	51	55	53	51	68	79	37	33	51	32	35	59	64	36	76
Des Moines, Iowa	55	62	54	52	54	76	57	41	45	43	33	60	69	34	52	57	47	44	68	51	43	84
Detroit, Mich	47	58	47	46	49	70	51	40	48	41	50	59	79	41	65	68	55	55	80	62	53	93
Dubuque, Iowa	53	60	51	47	52	75	54	40	43	42	44	60	76	38	56	61	50	47	72	50	45	85
El Paso, Tex	70	77	68	67	70	89	70	54	61	58	61	67	78	36	53	58	32	47	71	92	50	88
Fort Worth, Tex	62	70	60	59	62	81	60	45	52	51	52	58	71	31	55	59	39	48	71	71	51	92
Green Bay, Wis	53	60	52	48	53	74	54	41	48	42	46	60	78	41	61	65	53	52	75	52	46	86
Hampton Roads, Va	49	58	48	48	51	68	55	45	51	52	64	60	83	48	77	78	62	67	89	83	66	107
Houston, Tex	64	71	61	60	64	83	63	46	55	50	57	59	72	33	61	65	43	54	77	80	57	98
Indianapolis, Ind	48	56	47	43	47	68	49	39	44	38	48	55	74	37	62	66	52	53	78	60	51	91
Johnsonville, Tenn	54	61	51	49	53	72	51	36	43	41	49	54	70	34	63	66	48	58	79	72	53	94
Kansas City, Mo	56	63	54	51	56	76	56	40	44	42	45	59	69	31	51	57	39	46	70	59	43	84
La Crosse, Wis	54	61	53	49	54	76	56	42	45	44	47	62	78	39	57	62	51	49	73	47	43	82
Lincoln, Nebr	58	65	57	55	57	79	59	44	47	46	44	63	79	35	48	54	43	40	67	55	39	80
Little Rock, Ark	57	64	54	52	56	76	55	38	45	43	47	54	67	29	59	63	44	54	75	70	57	97
Louisville, Ky	49	56	49	43	48	69	50	35	43	38	50	54	74	39	63	66	52	53	79	63	54	94
Madison, Ind	49	56	46	43	48	68	52	37	42	39	50	55	75	38	63	67	51	54	76	61	52	85
Minot, N. Dak	62	70	62	60	62	83	64	51	60	52	52	67	85	46	61	64	54	42	77	23	38	69
Muskogee, Okla	58	65	56	56	58	78	58	42	47	45	49	59	64	29	56	56	41	47	73	63	50	93
Nashville, Tenn	52	59	49	46	51	71	50	33	46	40	51	53	72	37	64	67	51	54	79	67	55	95
New Orleans, La	64	67	57	59	64	83	62	46	52	54	58	53	72	37	66	59	44	60	71	82	60	98
New York, N.Y	47	57	47	47	50	71	57	51	55	51	63	63	87	50	78	79	61	68	90	83	65	101
Oklahoma City, Okla	60	67	58	56	59	79	60	44	49	47	49	59	69	22	53	59	39	47	71	60	50	90
Peoria, Ill	52	59	48	47	51	72	52	41	43	41	44	57	73	36	59	63	49	50	74	60	50	90
Philadelphia, Pa	46	55	46	47	48	68	57	47	53	50	61	61	91	49	76	77	64	65	89	82	63	103
Phoenix, Ariz	77	85	75	75	77	96	77	63	70	67	70	76	85	43	59	63	28	52	70	91	55	78
Pittsburgh, Pa	44	47	44	39	41	69	52	41	47	44	54	60	85	43	69	71	58	58	83	68	57	97
Portland, Oreg	82	90	81	82	83	102	83	71	77	76	76	87	101	59	66	62	48	58	68	69	35	50
Portsmouth, N.H	51	60	51	51	54	74	61	53	58	56	65	66	90	53	81	81	64	70	93	87	68	108
Raleigh, N.C	50	59	48	49	52	69	56	46	53	53	65	57	84	46	77	78	60	68	90	84	67	108
Rapid City, S. Dak	63	70	62	59	64	84	64	52	58	54	50	69	82	42	50	56	45	34	68	47	38	79
Spokane, Wash	77	84	76	76	77	97	78	66	72	71	70	83	99	56	64	60	54	56	66	58	42	51
Salt Lake City, Utah	72	79	71	70	72	92	73	61	64	62	61	76	87	45	50	47	36	41	54	71	48	66
St. Louis, Mo	52	59	50	47	51	72	52	38	38	38	44	55	71	34	57	62	48	49	74	64	48	89
St. Paul, Minn	57	63	55	53	55	76	57	44	49	44	47	63	84	38	56	61	51	47	74	43	40	80
Tampa, Fla	61	69	58	59	62	79	65	47	57	53	67	58	82	47	80	80	61	70	90	92	70	111
Wichita, Kans	59	66	57	55	59	78	59	45	48	46	46	60	72	29	50	56	40	44	69	63	47	87
Yazoo City, Miss	57	65	54	52	57	81	58	44	46	44	54	56	69	34	60	59	46	57	77	73	60	100

1/ Coal producing districts as defined by the Federal Bureau of Mines.

After the preliminary distribution has been attained, the total coal tonnage demanded from each district is summed. This summation is then compared with the total possible district output as presented in the Project Independence Blueprint (table C-1) for 1985. State's demand in excess of supply from a particular district are redirected to an alternate least-cost source of supply. This is done for the entire unconstrained matrix according to a least-cost transportation algorithm utilizing the delivered cost of coal as previously developed. This method of reapportionment can be justified on the basis that a consumer paying a lower transportation cost will be able to bid a higher price for disputed coal.[14] In cases where two (or more) alternate sources of supply have equal delivered costs (a tie), the supply source having the minimum transport distance is chosen. The unconstrained origin-destination matrix along with its discontinuities in supply is presented in table 15. The constrained origin-destination matrix is given in table 16 (see appendix C).

Development and Comparison of Transportation Cost Functions for Water and Rail (5)

With the projected origin-destination matrix for coal movements in 1985 established, a method of choosing between modes of delivery is necessary. Therefore, a matrix describing the cost per ton for the delivery of coal between an origin-destination pairing was constructed for both water and rail.

The average cost functions for transportation of coal by rail are as follows:

For distances ≤ 300 miles,

$$Y' = 114 + 1.236X - 0.00081X^2.$$

For distances >300 miles,

$$Y = 193 + 0.396X,$$

where Y = cost in cents per ton, 1973 dollars,

and X = distance in miles.[15]

Table 17 represents the cost matrix expressed in cents per ton that is developed when distances between origin-destination pairings are applied to the rail cost function.

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[14] An average delivered cost is used for States containing multiple consumption centers.

[15] The analysis of the rail average practice cost function in IC 8614 (25) was updated by applying ICC expartes as an indication of rate increases. See appendix B for details.

TABLE 15. - Projected distribution of bituminous coal and lignite by origin-destination in the United States, 1985 (unconstrained)

(Thousand short tons)

Destination	Coal producing districts 1/																				Total consumption
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23	
Alabama..........	0	0	0	0	923	1,789	12,855	2,237	0	0	30,948	0	0	0	0	0	0	0	0	0	48,752
Arizona..........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,936	0	2,037	0	0	13,973
Arkansas.........	0	0	0	0	117	527	0	0	0	0	78	264	7,794	0	0	0	0	0	0	0	8,780
Colorado.........	97	0	0	0	32	68	0	0	0	0	0	424	0	1,645	14,231	0	6,233	0	0	0	21,010
Delaware.........	1,296	21	285	0	138	1,065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,805
Dist. of Columbia.	55	0	151	0	55	1,053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,314
Florida..........	0	0	0	0	0	4,398	4,338	507	1,048	0	949	0	0	0	0	0	0	0	0	0	11,240
Georgia..........	0	0	0	0	0	11,594	11,438	1,339	2,763	0	2,499	0	0	0	0	0	0	0	0	0	29,633
Idaho............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	175	0	488	755
Illinois.........	0	0	32	0	924	4,854	3,313	54,139	791	0	0	125	0	0	37	0	0	0	0	11,437	75,652
Indiana..........	871	1,921	0	10	7,044	12,424	11,134	11,456	37,789	0	0	0	0	0	0	0	0	0	0	3,205	85,854
Iowa.............	0	0	0	0	122	285	1,358	8,925	46	1,514	0	0	313	0	35	0	3,253	0	0	0	15,851
Kansas...........	0	0	0	0	0	0	0	0	0	0	0	19	7,172	0	618	0	3,335	0	0	0	11,144
Kentucky.........	0	0	62	0	345	9,784	33,292	5,860	936	0	0	0	0	0	0	0	0	0	0	0	50,279
Louisiana........	0	0	0	0	29	137	0	0	0	0	20	69	2,038	0	0	0	0	0	0	0	2,293
Maryland.........	8,988	151	1,966	0	1,163	7,381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19,649
Massachusetts.....	29	0	50	0	21	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113
Michigan.........	2,311	270	9,115	21,541	2,964	19,428	2,954	2,092	633	0	0	0	0	0	0	0	0	0	0	231	61,539
Minnesota........	0	0	85	32	451	2,798	751	3,608	559	0	0	0	23	0	0	0	225	0	2,938	8,007	19,477
Mississippi.......	0	0	0	0	60	116	840	146	0	0	2,021	0	0	0	0	0	0	0	0	0	3,183
Missouri..........	0	0	0	0	404	1,341	487	18,826	0	0	140	0	10,964	0	26	0	2,088	0	0	0	34,276
Montana..........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,280	2,493	0	7,068	10,841
Nebraska..........	0	0	0	0	0	0	0	0	0	0	0	19	7,451	0	645	0	3,461	0	0	0	11,576
Nevada............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,793	0	2,312	0	0	12,105
New Hampshire.....	14	2	1,730	0	10	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,774
New Jersey........	874	0	527	4	95	340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,840
New Mexico........	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	15,557	0	0	0	0	15,585
New York..........	7,309	3,840	4,104	137	149	3,530	0	0	0	0	0	0	0	0	0	0	0	102	0	0	19,171
North Carolina....	0	0	39	0	931	44,243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45,213
North Dakota......	0	0	0	0	0	8	4	0	0	0	0	0	0	0	0	0	250	0	3,583	0	3,845
Ohio..............	1,861	9,179	9,671	62,802	4,535	32,247	2,852	0	828	0	0	0	0	0	0	0	0	0	0	0	123,975
Oklahoma..........	0	0	0	0	156	633	0	0	0	0	107	312	9,047	0	0	0	0	0	0	0	10,255
Oregon............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	99	106
Pennsylvania......	41,878	33,497	13,824	278	5,028	10,623	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103,128
South Carolina....	0	0	0	0	0	12,781	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,781
South Dakota......	0	0	0	3	0	23	9	0	0	0	0	0	0	0	0	0	912	0	13,136	0	14,083
Tennessee.........	0	0	0	0	184	15,499	18,844	1,436	800	0	392	0	62	0	0	0	0	0	0	0	37,217
Texas.............	0	0	0	0	780	3,452	0	0	0	0	536	1,736	50,674	0	0	0	0	0	0	0	57,178
Utah..............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,732	0	86	7,448	0	0	10,266
Virginia..........	11	0	0	0	727	11,464	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,202
Washington........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	157	0	3,629	3,887
West Virginia.....	3,598	5,304	19,998	2,627	1,209	23,960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56,696
Wisconsin.........	648	0	520	601	245	4,471	5,370	11,184	2,616	0	0	0	0	0	0	0	1,023	0	0	64	26,742
Wyoming...........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,274	0	0	0	15,274
Canada............	1,701	3,027	7,196	507	2,139	8,471	143	0	0	0	0	0	0	0	0	0	0	0	0	0	23,184
Mexico............	0	0	0	0	0	0	0	182	0	0	0	259	0	0	0	0	0	0	0	0	441
Other exports.....	3,955	0	2,478	0	19,384	25,558	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51,375
Total........	75,496	55,212	71,833	88,542	50,364	276,376	109,982	121,937	48,809	1,514	37,690	3,255	95,538	1,645	18,324	37,286	35,896	14,728	19,657	34,228	1,198,312

1/ Coal producing districts as defined by the Federal Bureau of Mines.

TABLE 16. - Projected distribution of bituminous coal and lignite by origin-destination in the United States, 1985 (constrained)

(Thousand short tons)

Destination	Coal producing districts 1/																				Total consumption
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23	
Alabama...........	0	0	0	0	923	1,789	5,020	2,237	0	0	38,783	0	0	0	0	0	0	0	0	0	48,752
Arizona...........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,936	0	2,037	0	0	13,973
Arkansas..........	0	0	0	0	117	527	0	0	0	0	78	264	7,794	0	0	0	0	0	0	0	8,780
Colorado..........	97	0	0	0	32	68	0	0	0	0	0	0	0	1,250	11,139	0	6,233	0	2,191	0	21,010
Delaware..........	798	21	285	0	636	1,065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,805
Dist. of Columbia.	55	0	151	0	55	1,053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,314
Florida...........	0	0	0	0	0	4,398	4,338	507	1,048	0	949	0	0	0	0	0	0	0	0	0	11,240
Georgia...........	0	0	0	0	0	11,594	11,438	1,339	2,763	0	2,499	0	0	0	0	0	0	0	0	0	29,633
Idaho.............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	175	0	488	755
Illinois..........	0	0	32	0	924	4,854	2,254	54,139	791	0	0	125	0	0	37	0	0	0	1,059	11,437	75,652
Indiana...........	871	1,921	0	10	7,044	12,424	8,623	11,456	36,571	0	0	0	0	0	0	0	2,511	0	1,218	3,205	85,854
Iowa..............	0	0	0	0	122	285	1,358	0	46	1,695	0	0	313	0	35	0	3,253	0	673	8,071	15,851
Kansas............	0	0	0	0	0	0	0	0	0	0	0	19	0	0	618	0	10,507	0	0	0	11,144
Kentucky..........	0	0	62	0	345	13,754	29,322	5,860	936	0	0	0	0	0	0	0	0	0	0	0	50,279
Louisiana.........	0	0	0	0	29	137	0	0	0	0	20	69	2,038	0	0	0	0	0	0	0	2,293
Maryland..........	8,988	151	1,966	0	1,163	7,381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19,649
Massachusetts.....	29	0	50	0	21	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113
Michigan..........	0	270	9,115	21,541	2,964	19,428	2,954	2,092	633	0	0	0	0	0	0	0	0	0	2,311	231	61,539
Minnesota.........	0	0	85	32	451	2,798	751	3,608	559	0	0	0	23	0	0	0	225	0	2,938	8,007	19,477
Mississippi.......	0	0	0	0	60	116	840	146	0	0	2,021	0	0	0	0	0	0	0	0	0	3,183
Missouri..........	0	0	0	0	404	1,341	487	14,298	0	0	140	0	10,964	0	26	0	6,616	0	0	0	34,276
Montana...........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,280	0	0	9,561	10,841
Nebraska..........	0	0	0	0	0	0	0	0	0	0	0	19	0	0	645	0	3,461	0	0	7,451	11,576
Nevada............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,800	0	2,312	0	4,993	12,105
New Hampshire.....	14	2	1,730	0	10	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,774
New Jersey........	874	0	527	4	95	340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,840
New Mexico........	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	6,799	4,958	0	0	4,800	15,585
New York..........	7,309	3,840	4,104	137	149	3,530	0	0	0	0	0	0	0	0	0	0	0	102	0	0	19,171
North Carolina....	0	0	39	0	931	44,243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45,213
North Dakota......	0	0	0	0	0	8	4	0	0	0	0	0	0	0	0	0	250	0	3,583	0	3,845
Ohio..............	0	9,179	4,943	52,315	4,539	52,171	0	0	828	0	0	0	0	0	0	0	0	0	0	0	123,975
Oklahoma..........	0	0	0	0	249	633	0	0	0	0	107	219	9,047	0	0	0	0	0	0	0	10,255
Oregon............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0	99	106
Pennsylvania......	40,065	33,310	13,824	278	5,028	10,623	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103,128
South Carolina....	0	0	0	0	0	12,781	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,781
South Dakota......	0	0	0	3	0	23	9	0	0	0	0	0	0	0	0	0	912	0	13,136	0	14,083
Tennessee.........	0	0	0	0	184	15,499	18,844	1,436	800	0	392	0	62	0	0	0	0	0	0	0	37,217
Texas.............	0	0	0	0	780	3,452	0	0	0	0	536	523	27,039	0	0	0	28,848	0	0	0	57,178
Utah..............	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,938	3,328	0	0	10,266
Virginia..........	11	0	0	0	727	11,464	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,202
Washington........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	157	0	3,629	3,887
West Virginia.....	0	5,304	19,998	2,627	4,807	23,960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56,696
Wisconsin.........	648	0	520	601	245	4,471	0	0	0	0	0	0	0	0	0	0	1,023	0	7,986	11,248	26,742
Wyoming...........	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,274	0	0	0	15,274
Canada............	1,701	3,027	7,196	507	2,139	8,471	143	0	0	0	0	0	0	0	0	0	0	0	0	0	23,184
Mexico............	0	0	0	0	0	0	0	182	0	0	0	259	0	0	0	0	0	0	0	0	441
Other exports.....	3,955	0	2,478	0	19,384	25,558	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51,375
Total........	65,415	57,025	67,105	78,055	54,557	300,270	86,385	97,300	44,975	1,695	45,525	1,525	57,280	1,250	12,500	22,535	88,485	8,115	35,095	73,220	1,198,312

1/ Coal producing districts as defined by the Federal Bureau of Mines.

TABLE 17. - Rail cost matrix, cents per ton, 1973 dollars

Destination	Origin - Coal producing districts 1/																					
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Albuquerque, New Mex............	949	896	916	884	879	911	891	738	696	724	632	743	533	450	382	500	369	511	580	954	642	1,006
Atlanta, Ga.....................	577	512	505	469	512	509	392	351	440	390	570	298	477	552	797	906	888	920	985	852	954	744
Baltimore, Md...................	338	323	401	357	340	408	515	524	526	520	650	509	852	769	915	1,033	1,201	989	1,113	854	1,019	1,365
Billings, Mont..................	937	885	929	896	868	924	903	797	743	797	605	901	829	745	453	571	817	324	440	505	114	559
Birmingham, Ala.................	561	509	502	469	492	507	439	313	380	352	517	114	402	486	737	855	918	834	935	796	901	1,267
Boise, Idaho....................	1,137	1,084	1,122	1,089	1,067	1,116	1,096	954	925	937	763	1,059	923	839	547	471	900	592	402	728	416	460
Boston, Mass....................	443	458	468	494	474	507	648	687	638	658	738	674	834	883	1,002	1,123	1,205	1,110	1,202	965	1,102	1,453
Buffalo, N.Y....................	317	381	371	330	313	470	460	470	442	465	542	559	771	688	807	925	1,106	881	1,005	745	907	1,257
Carson City, Nev................	1,228	1,176	1,218	1,185	1,178	1,206	1,193	1,143	993	1,025	872	1,163	986	902	604	540	633	544	468	968	578	642
Charleston, S.C.................	527	550	496	562	550	501	482	484	534	526	709	410	787	703	936	1,054	1,133	1,025	1,083	935	1,092	1,459
Charleston, W.Va................	377	324	320	385	397	210	408	371	379	393	530	538	587	622	770	878	1,036	860	929	730	891	1,242
Cheyenne, Wyo...................	825	772	810	777	755	805	785	642	589	625	451	747	611	528	236	353	599	346	433	724	411	775
Chicago, Ill....................	443	378	419	348	391	426	391	334	335	372	335	451	471	507	599	720	802	708	799	561	699	1,050
Cincinnati, Ohio................	370	318	410	344	393	408	347	384	314	320	446	383	492	541	689	817	924	779	818	645	810	1,029
Cleveland, Ohio.................	383	262	408	226	216	361	326	397	388	345	469	486	579	615	734	852	1,033	808	932	673	834	1,184
Columbia, S.C...................	511	499	481	511	499	450	431	433	482	475	658	359	736	652	885	1,003	1,082	974	967	884	1,041	1,408
Denver, Colo....................	850	785	803	748	772	811	776	649	586	616	463	737	574	486	114	410	461	355	381	667	453	817
Des Moines, Iowa................	572	520	564	532	503	559	539	412	359	385	114	517	325	417	463	572	812	539	608	484	605	972
Detroit, Mich...................	362	409	375	395	375	382	383	396	420	344	442	486	578	601	707	825	1,007	782	905	646	807	1,157
Dubuque, Iowa...................	504	452	483	418	435	527	471	400	317	355	327	525	511	509	543	652	891	618	688	481	642	993
El Paso, Tex....................	972	919	930	897	902	924	904	736	726	737	655	709	561	477	482	600	468	611	680	1,054	742	1,067
Fort Worth, Tex.................	769	717	710	707	700	705	624	511	519	555	476	466	379	333	511	620	623	640	663	770	771	1,137
Green Bay, Wis..................	515	463	497	426	469	504	469	412	413	370	370	529	554	585	640	749	966	728	785	509	670	1,021
Hampton Roads, Va...............	412	400	381	432	414	350	496	506	503	582	719	507	690	765	941	1,071	1,179	1,052	1,122	922	1,084	1,434
Houston, Tex....................	810	758	751	718	741	746	726	533	589	536	590	477	399	391	628	746	735	757	826	880	888	1,253
Indianapolis, Ind...............	392	340	355	322	323	350	330	374	337	258	408	392	467	503	650	768	935	739	848	611	772	1,122
Johnsonville, Tenn..............	544	492	484	452	479	458	399	292	302	340	426	368	348	423	674	783	836	845	868	771	810	1,176
Kansas City, Mo.................	610	545	551	509	532	559	524	397	336	364	348	485	343	329	445	566	623	601	645	595	609	975
LaCrosse, Wis...................	551	498	530	464	481	574	518	446	363	401	385	571	557	555	551	678	918	645	714	434	595	945
Lincoln, Nebr...................	648	595	640	607	578	635	614	488	410	460	320	585	587	444	384	493	730	460	561	541	526	892
Little Rock, Ark................	618	566	559	530	549	554	486	347	351	391	390	345	287	295	604	713	747	755	778	747	885	1,250
Louisville, Ky..................	416	363	428	324	346	351	354	272	315	261	436	348	446	536	663	781	948	753	861	655	820	1,186
Madison, Ind....................	409	357	349	317	341	348	410	327	277	282	442	379	473	522	669	798	905	760	798	625	791	1,010
Minot, N. Dak...................	772	719	764	730	702	758	738	667	701	599	479	701	721	707	632	741	978	502	819	114	505	680
Muskogee, Okla..................	656	603	613	628	605	618	568	451	391	423	417	480	205	301	532	532	672	621	730	653	752	1,156
Nashville, Tenn.................	490	437	431	398	420	425	357	226	369	317	456	333	397	480	683	801	913	773	881	715	840	1,206
New Orleans, La.................	823	649	642	715	758	755	699	535	507	633	604	334	405	487	724	604	759	886	684	910	955	1,253
New York, N.Y...................	353	367	378	403	383	416	557	662	578	567	694	583	774	823	959	1,080	1,150	1,066	1,159	922	1,059	1,320
Oklahoma City, Okla.............	702	650	660	627	633	655	635	482	439	485	417	486	339	114	486	604	625	614	684	608	745	1,110
Peoria, Ill.....................	488	435	402	403	404	442	411	410	320	340	326	436	429	456	597	706	869	672	741	617	739	1,105
Philadelphia, Pa................	328	331	344	401	348	347	547	557	541	553	658	547	871	787	922	1,040	1,210	997	1,120	915	1,022	1,373
Phoenix, Ariz...................	1,177	1,124	1,123	1,090	1,086	1,118	1,098	945	919	930	838	946	740	656	599	708	381	729	638	1,038	859	869
Pittsburgh, Pa..................	263	114	295	215	166	357	409	419	404	415	520	509	733	650	785	903	1,072	859	983	724	885	1,235
Portland, Oreg..................	1,302	1,250	1,290	1,257	1,232	1,284	1,264	1,144	1,090	1,144	953	1,248	1,120	1,037	736	675	834	854	592	738	428	292
Portsmouth, N.H.................	456	468	480	506	486	519	660	699	656	670	750	686	846	895	1,014	1,135	1,217	1,122	1,214	977	1,114	1,465
Raleigh, N.C....................	432	420	401	452	435	370	517	526	527	602	739	423	707	717	936	1,071	1,130	1,062	1,142	943	1,104	1,454
Rapid City, S. Dak..............	788	736	779	709	751	787	751	680	649	630	438	755	648	630	423	532	768	324	600	431	509	875
Spokane, Wash...................	1,156	1,104	1,148	1,115	1,087	1,143	1,122	1,031	978	1,032	840	1,136	1,063	980	688	638	979	806	555	592	574	324
Salt Lake City, Utah............	1,030	978	1,015	983	961	1,010	990	899	795	823	657	948	770	687	419	325	574	485	255	770	712	624
St. Louis, Mo...................	487	435	445	412	418	440	420	341	207	275	328	383	372	408	555	673	840	644	753	673	712	1,078
St. Paul, Minn..................	627	536	579	547	519	574	554	483	452	415	380	608	708	519	544	662	909	618	742	381	542	893
Tampa, Fla......................	745	693	674	705	693	644	772	573	637	612	774	450	667	743	993	1,102	1,153	1,107	1,156	1,050	1,158	1,524
Wichita, Kans...................	678	625	636	603	608	631	610	513	415	441	364	517	410	303	423	541	654	551	621	655	682	1,049
Yazoo City, Miss................	631	579	552	540	572	690	575	496	383	404	514	407	332	407	610	610	798	834	834	795	945	1,312

1/ Coal producing districts as defined by Federal Bureau of Mines.

Because of the lack of published water cost information, data compiled from water carrier interviews were used to construct a barge cost function. Figure 8 depicts the least squares regression line through a plot of actual reported 1973 costs for coal transportation on the inland waterways. The equation[16] describing this line is as follows:

$$\underset{(23.7)}{Y = 61.5} + \underset{(0.034)}{0.244X}$$

where Y = the cost of water transportation expressed in cents per ton,

and X = the distance between an origin-destination pairing.

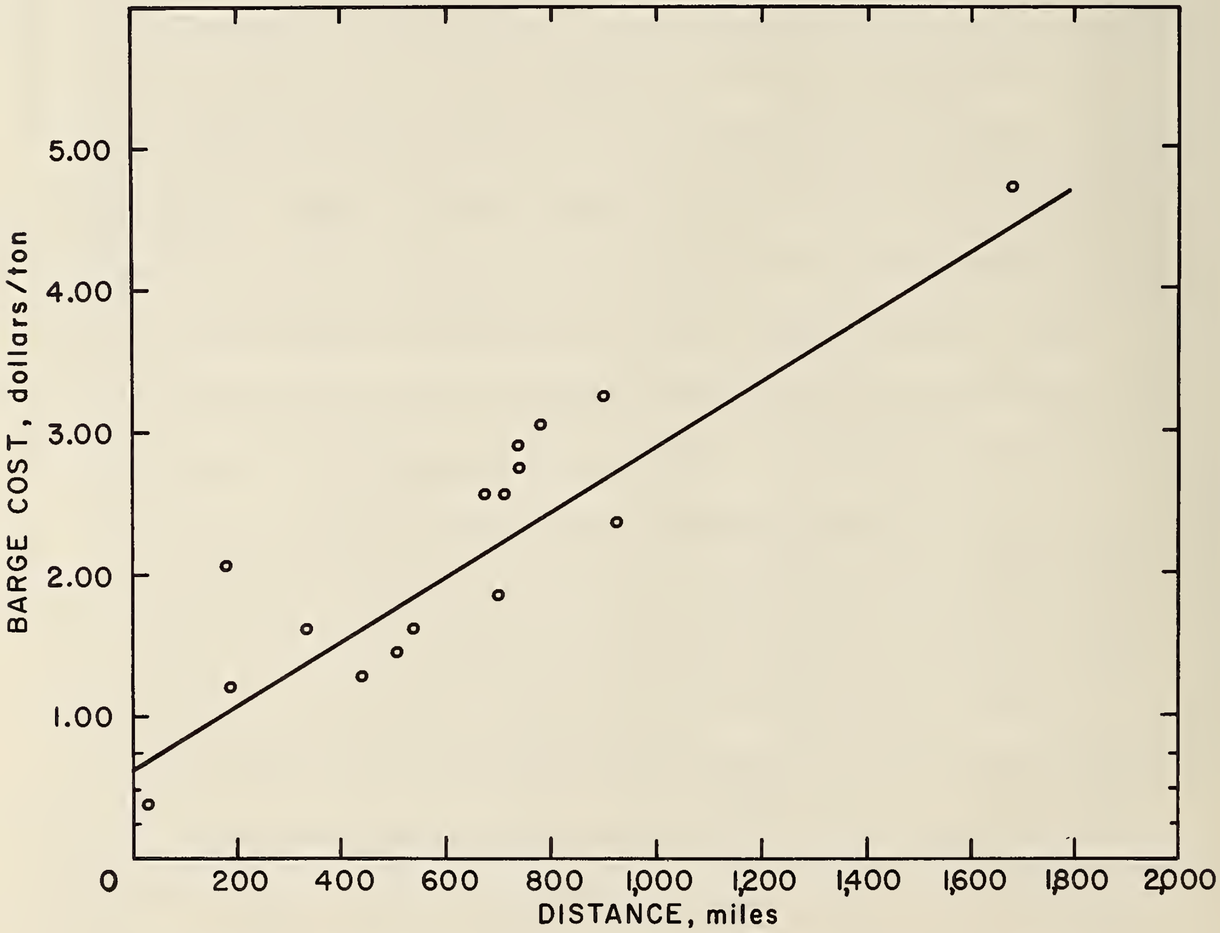

FIGURE 8. - Average 1973 cost function for barge transportation of coal.

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[16] The standard errors of the regression coefficients are given in parentheses below the coefficients.

The coefficient of determination (R^2) value for the cost function was 0.77. This indicates that 77 percent of the variance in Y is explained by the regression of Y on X. The F-test, performed at the 95-percent confidence level and 1,17 degrees of freedom, gave a value of 50.70. Therefore, it was concluded that Y is a linear function of X.

Table 18 displays the cost in cents per ton of reaching a water serviceable destination city from a coal producing district origin. This was accomplished in the following manner:

1. All water serviceable cities were identified.

2. Producing districts were paired with respective water terminals as a result of carrier interview.

3. Modes of delivery analogous to these water terminals were identified.

4. Distances were substituted into a delivery mode cost function to obtain the cost of delivery to the water terminal facilities (where applicable). In a case of truck utilization as the delivery mode, a flat rate of 5 cents per ton-mile was charged. Table 19 shows the centers of supply and their respective water terminals.

5. A matrix presenting the distances covered between the water terminals and the destination cities was developed and is presented in table 20. The final cost matrix (table 18) is a summation of the delivery cost to the water plus the cost incurred through river transportation. Comparison of the barge and rail rate matrices yields the lowest cost method of transporting coal from an origin to a destination. The least cost modes for the projected coal supply configuration were thus identified and will be used as data for subsequent analysis.

TABLE 18. - Barge cost matrix, cents per ton, 1973 dollars

Destination	Origin - Coal producing districts 1/																					
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Birmingham, Ala....	902	649	928	802	822	804	819	481	644	667	791	186	380	848	995	1,113	1,280	1,085	1,193	998	1,246	1,509
Charleston, W.Va...	393	140	392	293	313	267	332	226	484	405	632	721	431	688	836	954	1,121	925	1,034	839	1,086	1,351
Chicago, Ill.......	685	432	711	586	606	587	602	265	367	451	514	664	374	571	718	836	1,003	808	916	677	866	1,188
Cincinnati, Ohio...	431	178	457	331	351	333	349	138	420	342	568	658	367	624	772	890	1,057	861	970	773	1,023	1,285
Dubuque, Iowa......	695	442	721	595	615	597	612	275	376	460	523	555	385	580	727	845	1,012	817	925	507	933	1,019
Houston, Tex.......	865	612	891	765	785	767	782	445	607	630	755	420	343	811	959	1,077	1,244	1,048	1,157	962	1,210	1,473
Johnsonville, Tenn.	566	313	592	466	486	468	484	146	331	332	478	569	412	535	682	800	967	772	880	686	933	1,197
LaCrosse, Wis......	723	471	750	624	644	626	641	303	404	489	552	583	413	608	756	874	1,041	845	954	478	962	990
Little Rock, Ark...	687	435	714	588	608	589	605	267	429	453	577	446	109	634	781	899	1,066	871	979	784	1,032	1,296
Louisville, Ky.....	464	211	490	364	384	366	381	127	372	307	519	625	359	576	723	841	1,008	813	921	740	974	1,251
Madison, Ind.......	451	198	477	351	371	353	368	141	401	320	549	636	346	605	753	871	1,038	842	951	752	1,001	1,263
Muskogee, Okla.....	751	499	778	652	672	654	669	331	671	517	641	520	79	698	845	963	1,130	935	1,043	849	1,096	1,360
New Orleans, La....	766	513	792	666	686	668	683	346	508	531	656	321	244	712	859	977	1,145	949	1,057	863	1,111	1,374
Pittsburgh, Pa.....	314	61	470	268	288	346	382	277	535	456	682	772	482	739	886	1,004	1,171	976	1,084	890	1,137	1,402
St. Louis, Mo......	598	345	624	498	518	500	515	177	277	363	425	577	286	482	629	747	914	718	827	605	855	1,117
St. Paul, Minn.....	762	509	788	662	682	664	679	342	440	527	588	741	450	644	792	910	1,077	881	990	443	1,000	954
Tampa, Fla.........	930	677	956	830	850	832	847	510	672	695	820	423	408	876	1,024	1,142	1,309	1,113	1,222	1,027	1,275	1,539
Yazoo City, Miss...	699	446	725	599	619	601	616	279	441	465	588	418	127	645	792	910	1,077	882	990	795	1,043	1,307

1/ Coal producing districts as defined by the Federal Bureau of Mines (table B-1).

TABLE 19. - Coal-producing districts and their respective water terminal facilities

Origin district	Mileage to water terminal	Mode of delivery	Water terminal
1	122	Rail	Pittsburgh, Pa.
2	-	(1)	Do.
3	196	Rail	Cedar Grove, W. Va.
4	36	Truck	Powhatten Point, Ohio.
6	40	do.	Do.
7	74	Rail	Cedar Grove, W. Va.
8	115	do.	Huntington, W. Va.
9	-	(1)	Rockport, Ky.
10	76	Rail	Kellogg, Ill.
11	79	do.	Yankeetown, Ind.
12	399	do.	Kellogg, Ill.
13	25	Truck	Birminghamport, Ala.
14	-	(1)	Fort Smith, Ark.
15	542	Rail	Kellogg, Ill.[2]
16	914	do.	Do.[2]
17	1,212	do.	Do.[2]
18	1,634	do.	Do.[2]
19	1,140	do.	Do.[2]
20	1,414	do.	Do.[2]
21	475	do.	St. Paul, Minn.[2]
22	1,418	do.	Havana, Ill.[2]
23	1,767	do.	St. Paul, Minn.[2]

---

[1] Private railroad, conveyor, tramway, etc., effecting a direct coal mine to barge loading system.

[2] Estimates based on existing or planned facilities and/or current practices.

TABLE 20. - Barge distance matrix, miles

Destination	Origin - Coal producing districts [1]																					
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Birmingham, Ala....	2,407	2,407	2,218	2,297	2,297	2,218	2,098	1,721	1,553	1,635	1,553	0	1,305	1,553	1,553	1,553	1,553	1,553	1,553	2,275	1,764	2,275
Charleston, W. Va..	323	323	20	213	213	20	101	674	898	563	898	2,194	1,515	898	898	898	898	898	898	1,625	1,108	1,625
Chicago, Ill.......	1,520	1,520	1,331	1,410	1,410	1,331	1,211	834	417	748	417	1,961	1,280	417	417	417	417	417	417	959	206	959
Cincinnati, Ohio...	478	478	289	368	368	289	171	312	636	302	636	1,933	1,252	636	636	636	636	636	636	1,354	847	1,354
Dubuque, Iowa......	1,560	1,560	1,371	1,450	1,450	1,371	1,251	874	454	788	454	1,511	1,324	454	454	454	454	454	454	264	481	264
Houston, Tex.......	2,256	2,256	2,067	2,146	2,146	2,067	1,947	1,570	1,402	1,484	1,402	959	1,154	1,402	1,402	1,420	1,402	1,402	1,402	2,128	1,613	2,128
Johnsonville, Tenn.	1,032	1,032	843	922	922	843	725	346	270	260	270	1,570	1,437	270	270	270	270	270	270	996	481	996
LaCrosse, Wis......	1,677	1,677	1,488	1,567	1,567	1,488	1,368	991	571	905	571	1,628	1,441	571	571	571	571	571	571	147	598	147
Little Rock, Ark...	1,529	1,529	1,340	1,419	1,419	1,340	1,220	843	675	757	675	1,108	193	675	675	675	675	675	675	1,401	886	1,401
Louisville, Ky.....	614	614	425	504	504	425	305	268	438	158	438	1,800	1,219	438	438	438	438	438	438	1,218	649	1,218
Madison, Ind.......	559	559	370	449	449	370	252	324	558	214	558	1,845	1,164	558	558	558	558	558	558	1,266	759	1,266
Muskogee, Okla.....	1,792	1,792	1,603	1,682	1,682	1,603	1,483	1,106	1,665	1,020	938	1,371	70	938	938	938	938	938	938	1,664	1,149	1,664
New Orleans, La....	1,850	1,850	1,661	1,740	1,740	1,661	1,541	1,164	996	1,078	996	553	748	996	996	996	996	996	996	1,722	1,207	1,722
Pittsburgh, Pa.....	0	0	343	110	110	343	309	882	1,106	772	1,106	2,403	1,722	1,106	1,106	1,106	1,106	1,106	1,106	1,834	1,317	1,834
St. Louis, Mo......	1,161	1,161	972	1,051	1,051	972	852	475	51	389	51	1,602	921	51	51	51	51	51	51	667	161	667
St. Paul, Minn.....	1,834	1,834	1,645	1,724	1,724	1,645	1,525	1,148	718	1,062	718	2,275	1,594	718	718	718	718	718	718	0	753	0
Tampa, Fla.........	2,523	2,523	2,334	2,413	2,413	2,334	2,214	1,837	1,669	1,751	1,669	970	1,421	1,669	1,669	1,669	1,669	1,669	1,669	2,395	1,880	2,395
Yazoo City, Miss...	1,576	1,576	1,387	1,465	1,465	1,387	1,267	890	721	808	721	950	269	721	721	721	721	721	721	1,445	931	1,445

[1] Coal producing districts as defined by the Federal Bureau of Mines (table B-1).

Analysis of Great Lakes, Truck, Conveyor, Pipeline, and Tidewater Modes of Transportation (6)

Great Lakes, truck, conveyor, pipeline, and tidewater methods of coal transportation were excluded from the cost analysis portion of this study because of the lack of data and the minor transport share of these modes. The modal shares for these methods of coal transportation are treated as follows:

1. Tonnage projections for 1985 were taken to be the same percentage contribution by mode in a particular origin-destination pairing as they were in 1973. That is, a truck contribution of 10 percent between a particular origin-destination in 1973 (according to the Bituminous Coal and Lignite Distribution (56)) would be held constant to 1985. The same was done for other modes under consideration in this section.

2. Conveyor operations were included with truck in all cases except Oregon where a major portion of coal consumption is delivered by one conveyor. In this case, conveyor capacity was used in calculating the contribution percentage.

3. Pipelines were not developed as a viable mode of transportation to be realized in 1985. The Black Mesa Operation is the only one in existence, and rated capacity was used to calculate its contribution to coal transportation. Litigation as to the various rights involved in pipeline construction should continue to retard future slurry transportation proposals. Table 21 portrays the contribution by mode to the total amount of coal moved between an origin district and a destination State in 1973.

Estimation of Modal Shares Assuming No Constraints (7)

The unconstrained modal share analysis is an estimation of the tonnage traveling by mode between an origin-destination pairing. In this analysis the available tonnage was projected to flow between a specific origin-destination by the least cost mode of delivery.

The unconstrained estimation of the modal shares comprising an origin-destination movement was accomplished in the following manner:

1. Modal proportion constants, as developed in the previous section, are utilized, where applicable, to delineate the amount of projected tonnage available to rail and/or water transportation.

2. The lowest cost mode--water or rail--for a particular origin-destination combination, as presented in the modal cost analysis, wins the entire available tonnage. This modal discrimination is justified because (1) it is theoretically possible in a constraint-free universe and (2) no known practical way to differentiate demand for mode exists.

The unconstrained modal distribution for the entire origin-destination 1985 tonnage matrix is presented in appendix G, table G-1.

TABLE 21. - Percent contribution to coal tonnage flow between an origin-destination by mode, 1973 1/

Consuming region	Supply districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Alabama: Truck..........	-	-	-	-	-	-	-	-	-	-	27.6	-	-	-	-	-	-	-	-	-
Colorado: Truck.........	-	-	-	-	-	-	-	-	-	-	-	-	-	59.3	21.8	-	-	-	-	-
Idaho: Truck............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79.0	-	-
Illinois: Truck.........	-	-	-	-	-	-	-	18.0	68.9	-	-	-	-	-	-	-	-	-	-	-
Indiana: Truck..........	-	-	-	-	-	-	-	.4	29.3	-	-	-	-	-	-	-	-	-	-	-
Iowa: Truck.............	-	-	-	-	-	-	-	.7	-	65.3	-	-	-	-	-	-	-	-	-	-
Kentucky: Truck.........	-	-	-	-	-	5.4	58.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Maryland: Truck.........	16.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan: Great Lakes...	-	100.0	35.1	21.6	90.2	64.2	61.0	95.3	98.8	-	-	-	-	-	-	-	-	-	-	-
Minnesota: Great Lakes..	-	-	100.0	100.0	100.0	86.1	-	6.0	100.0	-	-	-	-	-	-	-	-	-	-	-
Missouri: Truck.........	-	-	-	-	-	-	-	5.7	-	-	-	-	49.6	-	-	-	-	-	-	-
Montana: Truck..........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1
Nevada:																				
Truck..................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-
Pipeline...............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-	-	-
New Mexico: Truck.......	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-	-	-
New York:																				
Truck..................	22.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes............	.13	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Carolina: Truck...	-	-	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota: Truck.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	63.2	-
Ohio:																				
Truck..................	6.0	13.6	-	45.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes............	1.7	-	.15	.12	5.0	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oklahoma: Truck.........	-	-	-	-	-	-	-	-	-	-	-	-	26.3	-	-	-	-	-	-	-
Pennsylvania: Truck.....	57.7	27.7	-	40.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tennessee: Truck........	-	-	-	-	-	22.9	.26	-	-	-	96.6	-	-	-	-	-	-	-	-	-
Utah: Truck.............	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89.4	-	-
Virginia: Truck.........	-	-	-	-	3.6	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington: Conveyor....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0
West Virginia: Truck....	-	10.6	62.2	26.9	1.5	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin: Great Lakes..	100.0	-	100.0	100.0	86.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wyoming: Truck..........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	91.4	-	-	-
Canada: Great Lakes.....	98.8	100.0	99.8	94.6	95.9	98.8	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ Only truck, conveyor/tramway, pipeline, and Great Lakes modes are represented. Conveyor/tramway is included in truck unless otherwise indicated. Percentage refers to the portion contributed to coal flow between that particular origin district - destination region only.

Estimated River Capacity for Coal Transportation (8)

The unconstrained modal share analysis assumed a constraint-free universe in the transportation sectors. Although theoretically possible, real world occurrences have demonstrated otherwise.

A method of analysis was developed to estimate how minimum river capacity affects the inland waterway transportation of coal. This method, which uses projections for lock capacities and average length of coal haulage by river, proceeds as follows:

1. Tonnages projected to be moved by the unconstrained modal share analysis are listed by origin-destination. These origin-destinations, in turn, dictate distances to be covered on each river system (table 22).

2. A weighted (by annual tonnage) mean and standard deviation for length of haul on each river system is calculated. This is done using the distance 1 ton of coal is projected to move rather than on a shipment basis.[17] Table 23 portrays the result of these calculations.

3. One standard deviation above and below the mean is defined as the high and low boundary length of haul. Each river system is categorized as to the possible increase in unconstrained modal share coal tonnage over historic coal tonnage. If an excessive increase exists, the river is put through a sectionalization process using its own inherent boundary length of haul for coal traffic. This process, in combination with high and low Corps of Engineers' projections of lock capacities, assigns two capacity constraints to each section of the river in question (see appendix D).

4. Four maximum sectional capacity configurations were developed for each river by combining the high and low boundary lengths of coal haul with the high and low estimates of sectional capacity. They are--

No. 1. High section capacity, low boundary length of haul.

No. 2. Low section capacity, low boundary length of haul.

No. 3. High section capacity, high boundary length of haul.

No. 4. Low section capacity, high boundary length of haul.

Each configuration is referred to by number later in the text. The sectional configurations are presented in decreasing order of potential river capacity; that is, the transport capability for coal traffic on each river decreases as the sectionalization pattern is changed from the No. 1 through No. 4 configurations. This is because (1) the low boundary length of haul minimizes the effects of restrictive lock capacities and (2) the high estimate of lock capacity allows greater tonnage flow.

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[17] This manner of estimating the average length of haul destroys the possibility of a normal distribution in shipment size. The use of this method was justified because of the lack of (1) actual water carriage data and (2) a better known way to estimate future shipment sizes.

TABLE 22. - Unconstrained origin-destinations, river distances, and annual tonnages projected to move on the river systems in 1985

Origin-destination	Distance traveled on each river system, miles										Annual tonnage, thousand short tons
	Green	Kanawha	Tennessee	Upper Mississippi	Lower Mississippi	Ohio	Illinois	Arkansas	Gulf Intra-coastal Waterway	Alabama	
District 2 - Indiana........	-	-	-	-	-	559	-	-	-	-	1,921
District 2 - Ohio..........	-	-	-	-	-	478	-	-	-	-	7,935
District 2 - Pennsylvania...	-	-	-	-	-	[1]0	-	-	-	-	24,096
District 2 - West Virginia..	-	59	-	-	-	264	-	-	-	-	4,741
District 4 - Ohio..........	-	-	-	-	-	368	-	-	-	-	28,438
District 4 - West Virginia..	-	59	-	-	-	154	-	-	-	-	1,922
District 6 - West Virginia..	-	59	-	-	-	154	-	-	-	-	3,999
District 7 - Indiana........	-	77	-	-	-	293	-	-	-	-	7,044
District 7 - Louisiana......	-	77	-	-	871	714	-	-	-	-	29
District 7 - Mississippi....	-	77	-	-	594	714	-	-	-	-	60
District 7 - Ohio..........	-	77	-	-	-	212	-	-	-	-	1,881
District 7 - Pennsylvania...	-	77	-	-	-	266	-	-	-	-	5,028
District 8 - Indiana........	-	-	-	-	-	252	-	-	-	-	5,581
District 8 - Louisiana......	-	-	-	-	871	672	-	-	-	-	137
District 8 - Ohio..........	-	-	-	-	-	171	-	-	-	-	36,593
District 8 - Pennsylvania...	-	-	-	-	-	309	-	-	-	-	10,623
District 8 - West Virginia..	-	59	-	-	-	42	-	-	-	-	22,120
District 9 - Florida........	98	-	-	-	871	196	-	-	673	-	4,338
District 9 - Illinois.......	98	-	-	218	-	196	322	-	-	-	2,254
District 9 - Indiana........	98	-	-	-	-	326	-	-	-	-	8,623
District 9 - Iowa..........	98	-	-	580	-	196	-	-	-	-	1,358
District 9 - Kentucky.......	98	-	-	-	-	170	-	-	-	-	12,139
District 9 - Minnesota......	98	-	-	854	-	196	-	-	-	-	751
District 9 - Mississippi....	98	-	-	-	594	196	-	-	-	-	840
District 9 - Missouri.......	98	-	-	181	-	196	-	-	-	-	487
District 9 - Tennessee......	98	-	100	-	-	150	-	-	-	-	18,795
District 10 - Minnesota.....	-	-	-	718	-	-	-	-	-	-	3,393
District 11 - Tennessee.....	-	-	100	-	-	161	-	-	-	-	800
District 13 - Florida.......	-	-	-	-	-	-	-	-	574	396	949
District 13 - Louisiana.....	-	-	-	-	-	-	-	-	157	396	20
District 13 - Texas.........	-	-	-	-	-	-	-	-	563	396	536
District 14 - Arkansas......	-	-	-	-	-	-	-	193	-	-	264
District 14 - Texas.........	-	-	-	-	465	-	-	310	406	-	523
Districts 22 and 23 - Illinois.....	-	-	-	-	-	-	206	-	-	-	11,437
Total.................											229,655

[1] An actual distance is incurred and will be accounted for in subsequent sections.

TABLE 23. - Average length of haul and total tonnage calculations for projected 1985 coal traffic on the river systems[1]

River	Total coal tonnage, thousand short tons	Mean length of haul, miles	Standard deviation
Alabama	1,505	396.0	([2])
Arkansas	787	270.8	55.3
Green	49,585	98.0	([2])
Gulf Intracoastal Waterway	6,336	625.4	83.1
Illinois	13,691	225.1	43.0
Kanawha	46,824	64.4	8.2
Lower Mississippi	5,927	793.1	141.9
Ohio	212,533	202.0	119.8
Tennessee	19,595	100.0	([2])
Upper Mississippi	8,243	593.2	241.4
Mississippi River System and Gulf Intracoastal Waterway	229,655	304.6	282.7

[1] Based on the unconstrained modal share matrix.

[2] Data base prevented calculation.

Figure 9 shows the results of these calculations graphically. The solid bar depicts each river system with the estimated annual sectional capacities listed on each side. These capacities, in millions of tons, represent the high and low estimates for practical 1985 tonnage flows through the restricting lock in that section. The length of the sections is determined by the boundary length of haul. For example, the No. 1 capacity configuration (high section capacity, low boundary length of haul) for the Ohio River is represented by a boundary length of haul of 82 miles and annual sectional capacities in millions of tons of 103, 99, 83, 69, etc.

Constraining Effects of River Capacities on Projected Water and Rail Transportation (9)

Capacity constrains under various conditions have now been established for coal transportation on inland waterways. So that projected river capacities will not be exceeded, it is necessary to eliminate or reduce coal flow tonnages to be transported on the inland waterways between an origin-destination pairing.

This reduction in coal traffic on the waterways is effected on an individual origin-destination basis. Initially, one of the four possible capacity configurations is chosen to be held constant. The river sections to be traveled by an origin-destination routing are then listed, and the tonnage to be transported over them is recorded. This is done repetitively until all the origin-destinations have been accounted for and projected sectional tonnages have been summed. The projected sectional tonnages are then compared with the sectional capacity figures, and where necessary, a proportional reduction process is instituted against the origin-destinations traversing the section.

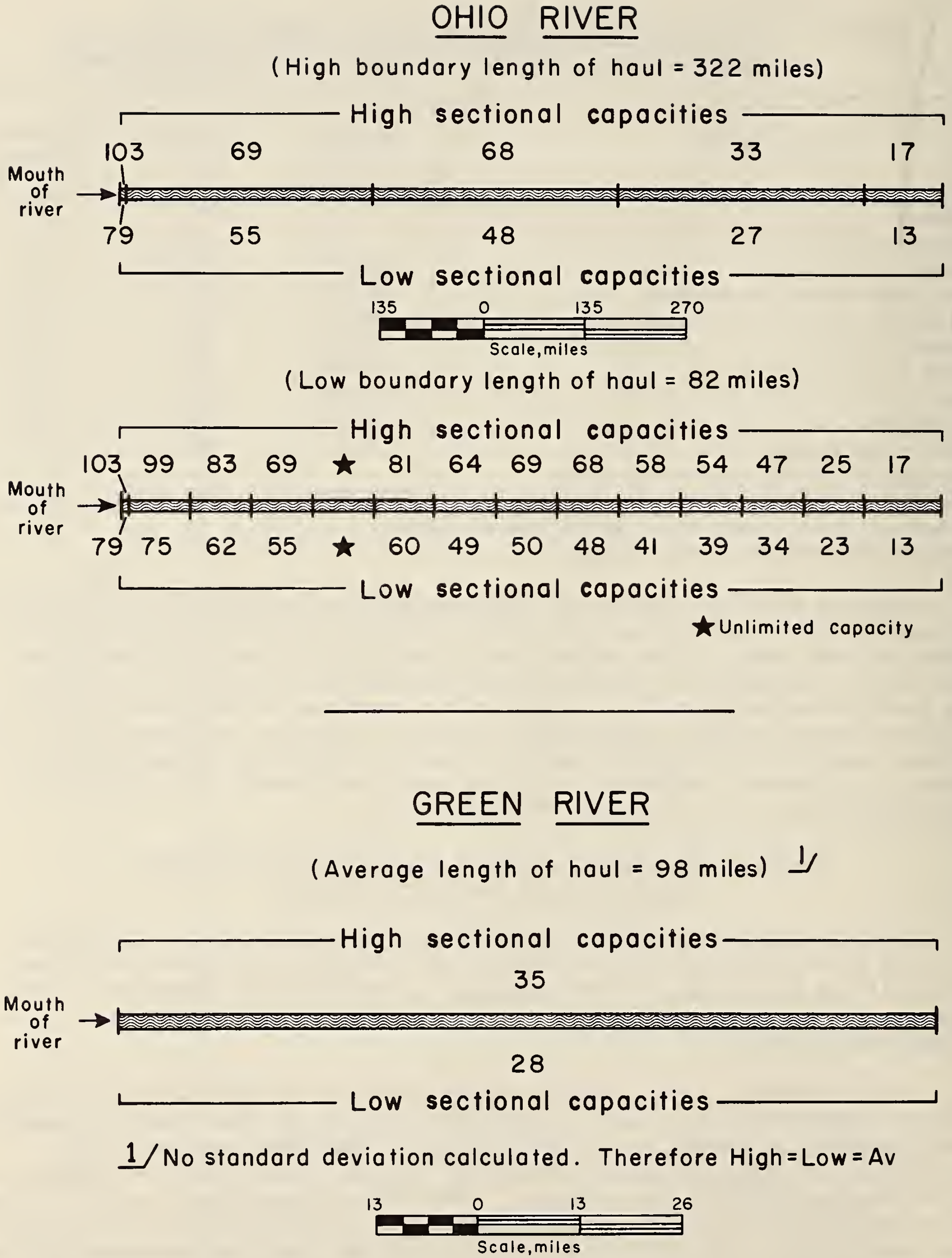
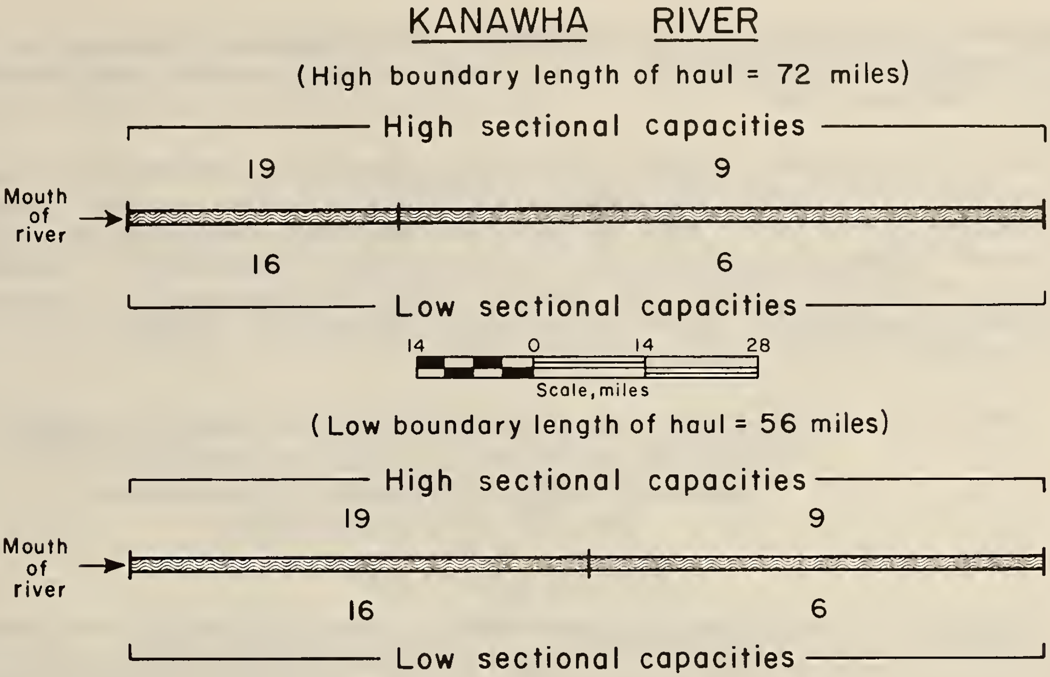


FIGURE 9. - Projected 1985 sectional capacity configurations for selected rivers, million short tons.


KANAWHA RIVER
(High boundary length of haul = 72 miles)
High sectional capacities
19
9
Mouth of river
16
6
Low sectional capacities
14
0
14
28
Scale, miles
(Low boundary length of haul = 56 miles)
High sectional capacities
19
9
Mouth of river
16
6
Low sectional capacities

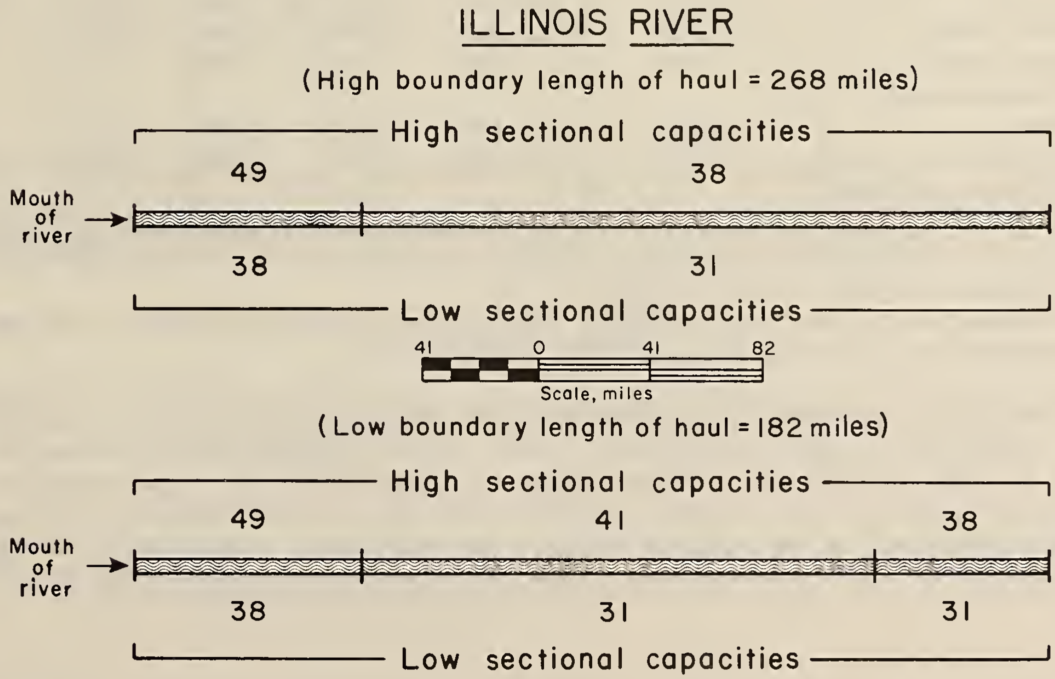

ILLINOIS RIVER
(High boundary length of haul = 268 miles)
High sectional capacities
49
38
Mouth of river
38
31
Low sectional capacities
41
0
41
82
Scale, miles
(Low boundary length of haul = 182 miles)
High sectional capacities
49
41
38
Mouth of river
38
31
31
Low sectional capacities

FIGURE 9. - Projected 1985 sectional capacity configurations for selected rivers, million short tons (Con.).

The reduction originates on the tributaries and progresses through the main river systems (see appendix E). The process is then repeated for another capacity configuration.

Since four capacity configurations were developed, the reduction process was generated four times. The result, presented in table 24, was a range of coal tonnages projected to move on the river sections comprising the Mississippi River System and Gulf Intracoastal Waterway. However, No. 4 sectional capacity configuration (low lock capacity, high boundary length of haul) has been deemed unacceptable due to its proposal for a drop in total coal traffic on the inland waterways from current levels.

TABLE 24. - Coal tonnage on the Mississippi and Gulf Coast river systems as generated by the unconstrained modal share, the four constrained modal shares, and 1972 actual shipments[1]

(Thousand short tons)

River	Unconstrained modal share	Constrained modal share				1972 shipments
		No. 1	No. 2	No. 3	No. 4	
Green River.........	49,585	34,995	27,997	34,995	27,997	16,191
Kanawha River.......	46,824	18,998	15,998	18,998	15,998	7,412
Tennessee River.....	19,595	12,840	10,432	12,840	10,432	11,965
Upper Mississippi...	8,243	6,500	5,879	6,500	5,879	12,092
Lower Mississippi...	5,927	3,992	3,280	4,016	3,283	11,775
Ohio River..........	212,533	132,949	104,053	100,396	71,817	65,089
Illinois River......	13,691	12,881	12,592	12,881	12,592	6,781
Arkansas River......	787	787	787	787	787	533
Gulf Intracoastal Waterway...........	6,336	4,807	4,251	4,807	4,251	4,933
Alabama rivers......	1,505	1,505	1,505	1,505	1,505	6,405
Mississippi and Gulf Coast river systems	229,655	149,971	121,175	117,518	[2]88,498	110,731

[1] 1972 coal tonnages taken from Waterborne Commerce of the United States--Calendar Year 1972, Part 2 (45).

[2] Constrained share No. 4 effected a drop in total water shipments and was, consequently, removed from further calculations.

The three remaining configurations for water transportation, when taken on an individual origin-destination basis, yield corresponding values for the amount of coal available to other modes of transportation. Upon removal of the proportional values for the constant methods of coal haulage, the coal tonnages required to be carried by rail are attained. Appendix G, tables G-2-G-4, display the three viable (according to present-day operations) modal shares of projected tonnage developed for each origin-destination.[18] Table 25 presents the aggregate projected 1985 coal transport shares by mode for both the constrained and unconstrained cases.

TABLE 25. - Projected 1985 coal transport shares, million short tons

Mode	Unconstrained share		Constrained shares					
			No. 1		No. 2		No. 3	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Rail..........	894.1	63.7	934.8	68.7	951.0	71.0	965.8	72.3
River and ex-river.....	229.7	16.4	150.0	11.0	121.2	9.1	117.5	8.8
Truck and conveyor.....	211.1	15.0	207.0	15.2	198.2	14.8	184.0	13.8
Great Lakes...	53.5	3.8	53.5	3.9	53.5	4.0	53.5	4.0
Tidewater.....	10.3	.7	10.3	.8	10.3	.7	10.3	.7
Slurry pipeline.....	4.8	.4	4.8	.4	4.8	.4	4.8	.4
Total[1]...	1,403.5	100.0	1,360.4	100.0	1,330.0	100.0	1,335.9	100.0

[1] Total includes duplications; bimodal shipments are included in both the rail and truck and conveyor modes.

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[18] Linear regression analysis performed on historic (1962-72) time series data for water shipments of coal on the inland waterways yielded the following function:

$$\underset{(838)}{Y = 77,135} + \underset{(329)}{2,938X},$$

where Y = annual coal tonnage on the inland waterway (thousand short tons), 1962-72,

X = time,

and coefficient of determination (R^2) and F-test values were 0.89 and 80, respectively (standard errors of the regression coefficients are given in parentheses).

Using this function for predictive purposes, coal shipments on the inland waterways would total 147.6 million tons in 1985. This is close to the water shipments estimate of 150 million tons in the No. 1 constrained modal share.

EQUIPMENT REQUIREMENTS FOR PROJECTED 1985 RAIL AND BARGE COAL TRANSPORTATION (10)[19]

In a progressing technology, average operating practice today combines the extremes, both the best and least efficient practices. With time, today's best becomes average (37).

Equipment requirements for projected 1985 coal transportation necessarily depend upon the level of operating efficiency attainable by 1985. If full technological implementation is assumed, developing a best practice operation level for 1973 will give an approximation of the average coal hauling practice in 1985. If full implementation is not achieved by 1985, then 1985 operating efficiencies will fall somewhere between 1973 average and best practices (1985 average practice).

The analysis of equipment requirements that follows has accounted for this range of operating efficiencies by developing equipment needs for both ends of the scale; that is, equipment estimates are presented for both 1973 and 1985 average practice levels of operation.

Rail

Average 1973 Practice

In 1973, a total of 397,158,000 short tons of coal was transported by the Nation's railroads for an average distance of 300 miles. The 1973 yearend serviceable hopper car stock for class I railroads (table 2) was 335,328 cars of 76.57-ton average size. About 63 percent of these, or 211,257 cars, were used for hauling coal. From these statistics, the average 1973 hopper car utilization is calculated:

$$\text{Hopper car utilization} = \frac{\text{Total ton-miles}}{\text{Total cars used}}$$

$$= \frac{(397{,}158{,}000)(300)}{211{,}257}$$

$$= 0.564 \times 10^6 \text{ ton-miles per car (76.57-ton size)}$$

$$= 0.737 \times 10^6 \text{ ton-miles per car (100-ton size).}$$

This utilization then provides a basis for projecting maximum 1985 hopper car needs. No gains in car use efficiencies over average 1973 practice are assumed other than an increase in hopper car average size to 100 tons. The

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[19] Truck, conveyor, Great Lakes, tidewater, and pipeline methods of coal transportation have not been considered in this analysis; truck and conveyor have been excluded because of widespread size distribution, relative ease of acquisition, and distance uncertainties; Great Lakes and tidewater, because of inadequate data and declining importance; and pipeline, because of an unsure future.

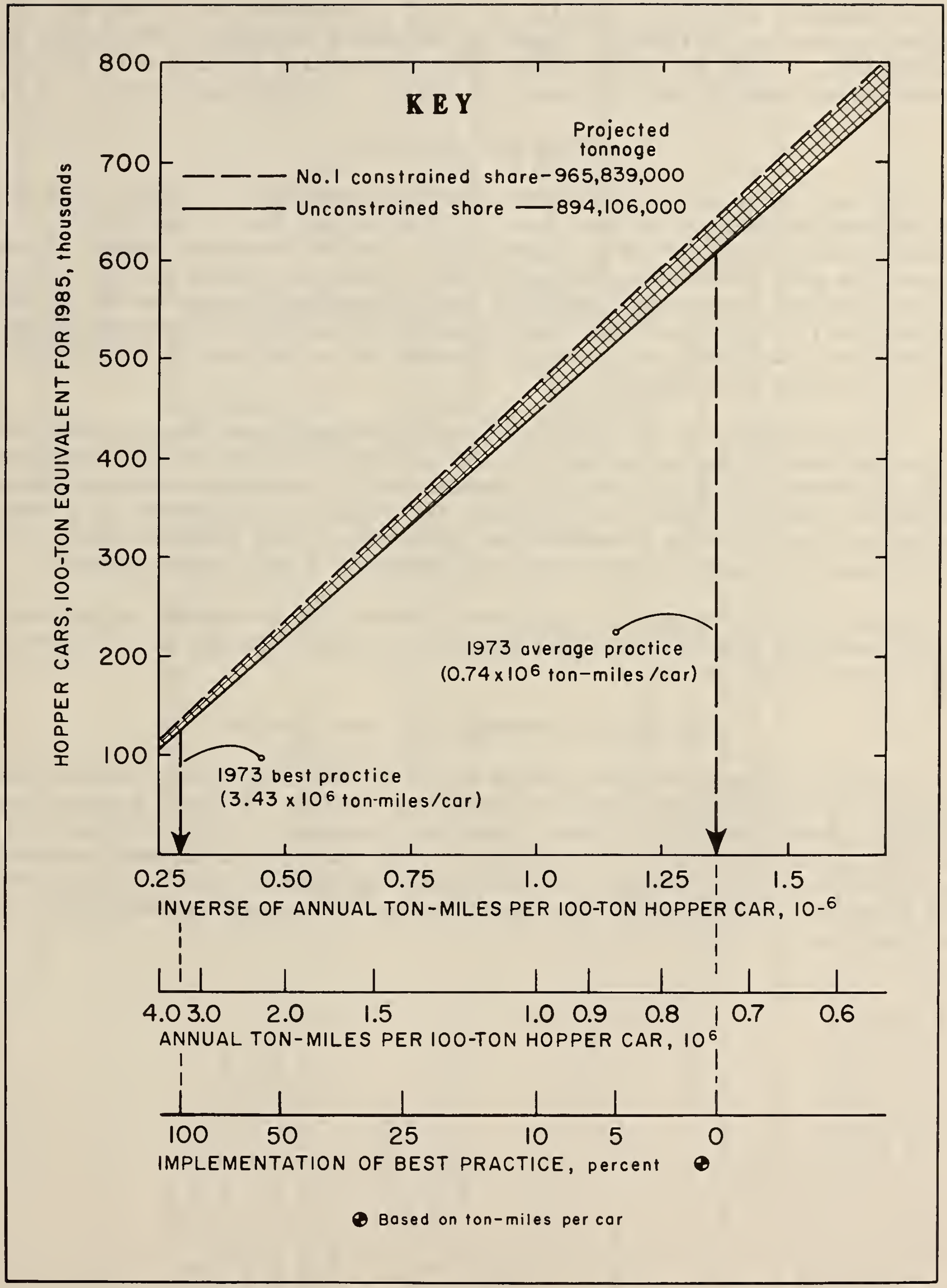

FIGURE 10. - Projected coal hopper car requirements, 1985.

four projections of total ton-miles for rail transportation in 1985 are divided by the car utilization factor to determine estimated 1985 hopper car requirements. These estimated requirements range from 604,500 cars for the unconstrained share to 642,500 cars for the No. 1 constrained share.

Best 1973 Practice

The best practice was estimated from 1973 experience of large efficient unit trains operating a 300-day year at 20 miles per hour. Therefore, a car in unit train service would be capable of 7.2×10^6 ton-miles annually. An increase in unit train share of rail traffic from one-fourth in 1973 to one-half in 1985 was estimated. Multiple car loading would thus decline to one-half the rail traffic in 1985. Best practice for multiple car loading was estimated at one-fourth the ton-mile capacity of a car used in unit trains or 1.8×10^6 ton-miles annually.

The two hopper car utilization factors developed were then applied to the origin-destination ton-miles for the one unconstrained and three constrained share estimates (tables 13 and G-1 through G-4). The origin-destinations generating the largest amount of ton-miles were summed to represent unit train operations; the break in ton-miles was selected so that about one-half the rail tonnage is moved by unit train (see appendix F for further detail).

Hopper car requirements, using best practice as developed, range from 125,700 cars for the unconstrained share to 141,600 cars for No. 1 constrained modal share (table 26).

Comparison of Average and Best Practice

Figure 10 shows how 1973 average and best practices relate and how they apply to the range of estimates of 1985 modal shares. At 1973 average practice, zero implementation of best practice is assumed, and each hopper car (100-ton) generates 0.74×10^6 ton-miles. The amount of equipment required for operation at 1973 average practice (zero implementation) is approximately five times the amount needed for operation at 100 percent implementation of best practice.

TABLE 26. - Coal transportation and equipment requirements for 1973 and 1985

Mode	Historic 1973	Uncon-strained modal share	Constrained modal shares[1]		
			No. 1	No. 2	No. 3
Rail:					
Total tons[2]....thousand short tons..	397,158	894,106	907,830	926,061	944,652
Total ton-miles....billions..	119.1	444.9	472.9	467.1	471.7
Average length of haul....miles..	300	512	521	504	499
Hopper cars--100-ton....	161,760	125,700	141,600	135,200	138,900
Hopper cars--76.6-ton[3]....	211,170	164,100	184,900	176,500	181,300
Average annual ton-miles/100-ton car equivalent....millions..	0.74	3.54	3.34	3.45	3.40
Locomotives....	2,580	6,900	7,800	7,400	7,600
River and ex-river:					
Total tons....thousand short tons..	104,679	229,655	149,971	121,175	117,518
Total ton-miles....billions..	36.6	71.8	49.4	39.8	37.5
Average length of haul....miles..	350	307	329	328	319
Barges:[4]					
900-ton....	-	1,210	550	470	440
1,400-ton....	-	2,640	2,000	1,580	1,560
Total....	[5]3,730	3,850	2,550	2,050	2,000
Total, 1,400-ton equivalent....	3,090	3,418	2,350	1,840	1,840
Towboats[6]....	570	405	260	210	205
Average annual ton-miles/1,400-ton barge equivalent..millions..	12.1	21.0	21.0	21.6	20.4

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[1] Refers to three tonnage configurations generated in the constrained modal share analysis. Equipment estimates were based on an estimated one-half the projected rail tonnage moved by unit trains in 100-ton hopper cars capable of 7.2×10^6 ton-miles per year (multiple car loading was one-fourth as great or 1.8×10^6 ton-miles). Assumed 5 locomotives required per 100 cars plus 10 percent for spares (appendix F).

[2] Includes all-rail and bimodal rail shipments.

[3] Average size hopper car used in 1974.

[4] Differential between barge size dictated by operational capacities of the rivers (appendix F).

[5] Average size barge in 1973 was 1,160 tons.

[6] 1973 historic towboats required for coal were estimated by authors.

Water

Average 1973 Practice

In 1973, 104,679,000 short tons of coal were transported on the inland waterways for an average distance of 350 miles. The 1973 stock of dry cargo barges was 14,904 with an average size of 1,160 tons. About 25 percent or 3,730 barges were used for hauling coal. From these statistics, average 1973 barge utilization was calculated:

$$\text{Average practice barge utilization} = \frac{\text{Total ton-miles}}{\text{Total barges used}}$$

$$= \frac{(104{,}679{,}000)(350)}{3{,}730}$$

$$= 9.82 \times 10^6 \text{ ton-miles per barge (1,140-ton)}$$

$$= 12.09 \times 10^6 \text{ ton-miles per barge (1,400-ton).}$$

This 1973 barge utilization is then used as a basis for projecting maximum 1985 barge needs. The four projections of total barge ton-miles in 1985 are divided by the 1973 average barge utilization to determine estimated 1985 coal barge requirements. These estimates range from 3,100 for the No. 3 constrained share to 5,940 barges for the unconstrained share.

Best 1973 Practice

The best practice operational standards for water transportation equipment in 1973 were estimated by establishing the maximum tow sizes, speeds, and barge sizes attainable on the major coal hauling river systems of the Inland Waterways. Utilizing these factors as they applied to individual origin-destinations, an estimate of the annual ton-miles generated by each tow was made. Dividing total ton-miles of coal traffic projected to flow between an origin-destination by the value for ton-miles per tow yielded the number of full size tows required for that service. Barge and towboat requirements were then based on the number of tows needed. For further details, see appendix F. The estimates of barges required to accommodate all water-serviceable origin-destinations ranged from 2,000 in the No. 3 constrained share to 3,850 in the unconstrained share (table 26).

Because the amount of equipment required for the water transportation of coal had to be estimated on an individual origin-destination basis, a ton-mile figure applicable to all geographical regions of service could not be developed. However, the weighted average for service to these regions was calculated to be 21 × 10^6 ton-miles per barge.

Comparison of Average and Best Practice

Figure 11 illustrates the relationship between ton-miles achieved per barge (efficiency) and the number of barges required. At 100-percent

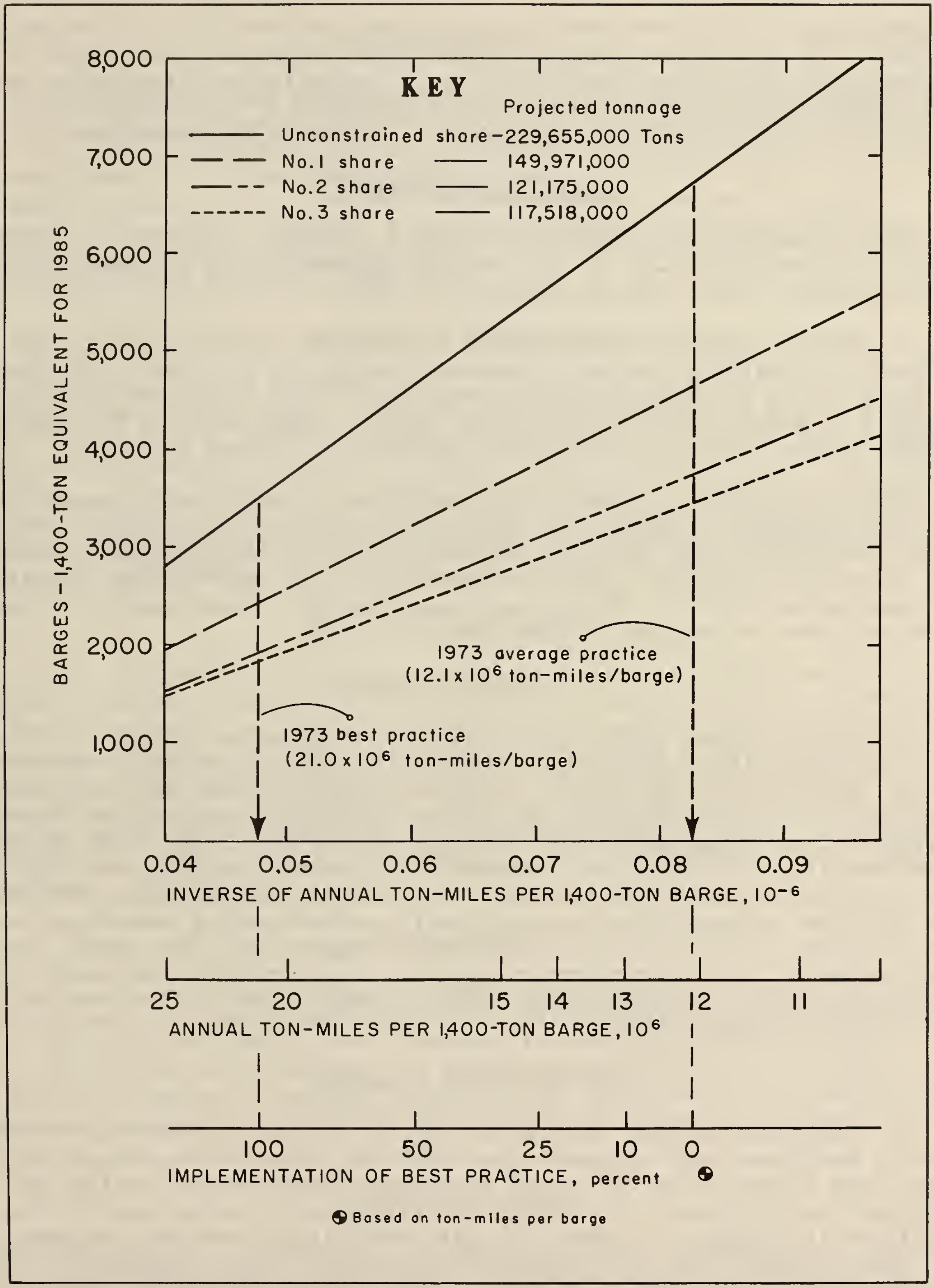

FIGURE 11. - Projected coal barge requirements, 1985.

implementation of 1973 best practice, each barge achieves 21 X 10^6 ton-miles per year. At zero-percent implementation of best practice (1973 average practice), the efficiency level is 12.1 X 10^6 ton-miles per barge. The amount of equipment required at zero-percent implementation of best practice is roughly 1-1/2 times the amount required at 100-percent implementation.

Analysis Implications

The transportation equipment needs are a function of the level of implementation of best practice. At 100-percent implementation, no expansion of 1973 equipment stocks would be required in 1985.

To achieve complete implementation of 1973 best practice by 1985, the efficiency of equipment use must increase fivefold for rail and 1-1/2 times for water. That is, the compounded annual growth rate of use efficiency as expressed in annual ton-miles per hopper car (or barge) required for complete implementation is about 14 percent for rail and 3.5 percent for water.

However, the recent trends in equipment use (as expressed by annual ton-miles per equipment) suggest that these growth rates may be unlikely. Use of hopper cars between 1964 and 1973 improved only 17 percent--an annual growth rate of about 1.6 percent. Barge utilization did not improve significantly in the same period. A 20- to 30-percent implementation of best practice, though optimistic, may be possible in 1985.

COLLATERAL FACTORS

Collateral factors may affect the efficient expansion of the coal transportation industries. Factors most evident are (1) coal conversion processes, usually located at the mine mouth, thus eliminating the need for bulk transportation; (2) slurry pipelines, an alternative mode for high-volume needs, in competition with large unit trains; (3) air quality standards, which determine environmentally acceptable coal reserves--a change in standards thus influences established origin-destinations; (4) mine size distribution limits the most efficient transportation systems, small isolated mining operations are less efficient to serve; (5) regulation by government may limit rapid, efficient expansion of coal transportation; (6) a lag in capital investment in the transportation industries may limit timely expansion; and (7) the uncertain futures for coal production.

Coal Conversion Processes

As technology advances and energy supplies change, the emergence of the multiple coal conversion processes (gasification, liquefaction, etc.) introduces a new factor to the derivation of future transportation matrices and consequent modal shares. Location, size, and method of production of these facilities all serve to delineate not only the delivery mode for raw coal, but also the method for end production distribution. The development of this new consumption sector was considered in the base publication for regional consumption (55); however, the extent of process application is unknown.

Slurry Pipelines

Slurry pipelines were eradicated from the coal transportation picture in 1985. Yet, the existence of the Black Mesa pipeline between Arizona and Nevada is in direct contrast to this assumption. The same factors that led to the development of the Black Mesa venture--namely, a massive area of production coupled with a cluster of large volume consumers--can and do exist throughout the country. However, legislative actions concerning riparian rights and applications of eminent domain render predictions for the realization time of slurry pipelines impossible.

Air Quality Standards

The consumption and delivered cost of coal matrices depend upon the location of the sources of supply. Imposing air quality standards upon the consuming sectors of coal not only dampens overall consumption, but also diverts centers of production to regions containing reserves of environmentally acceptable coal. The net effect is a distortion of the coal transportation network away from historic norms. Again, the publication (55) providing the base for the consumption projections accounted for the existence of these standards. However, the consequences of a change in policy can readily be seen.

Mine Size Distribution

Maximum efficiency in equipment utilization (best practice) was used throughout the study. Achieving the best practice usually results directly from the economies of scale realized in various forms of coal transportation. For example, operation of unit trains necessitates both a large source of supply and a high-volume consumer. To fully develop the low-cost, high-tonnage forms of coal transportation, the trend must continue toward large production mines in the range from 1 to 3 million tons per year. Retarding this shift will restrict efficient transportation practices and force resultant equipment needs to rise.

Regulation

Unwise regulatory practices since 1887 have decreased productivity in both rail and, to a lesser extent, truck transportation.[20] Reevaluation of policy and attitudes towards the transportation of bulk commodities with regard to these modes could lead to a restructuring of future cost functions. This restructuring would cause an overall shift in the modal share components of the coal transportation industry and a change in resultant equipment demands.

Capital Investment

Projections for the amount of equipment required to transport 1.2 billion tons of coal in 1985 assumed the extreme willingness and/or ability of the coal transportation firms to timely expand their physical plant. Actually inflation, unfavorable investment climates, and the financial conditions of the carriers involved may promote a conservative approach to commitment of funds for expansion of coal carrying capacity. This, in turn, would only amplify present inefficiencies in areas of coal transportation and, consequently, increase the amount of equipment required.

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[20] Water transportation is not included since a majority of coal is hauled under exempt, for-hire status.

Uncertain Futures for Coal Production

The uncertain futures for domestic coal production may limit transportation expansion. This is because production must necessarily lead the transportation industry. A long-term national policy for energy is needed to outline coal's future role. Without this policy, coal transportation may be serving an unsure market.

SUMMARY

Six basic modes of transportation are used for hauling coal in the United States. Of the nearly 600 million tons of coal shipped in 1973, all-rail movements accounted for 49 percent; river and ex-river, 18 percent; truck, 12 percent; conveyor, 8 percent; Great Lakes, 7 percent; and tidewater, 1 percent (unreported movements, 5 percent).

Historically, approximately 63 percent of the serviceable open-top hopper cars and 25 percent of the dry bulk cargo barges have been utilized for the transportation of coal by rail and water. For 1973, these figures represent roughly 234,730 hopper cars (76.57 tons per car) and 3,500 barges (1,140 tons per barge).

Determining the amount of equipment needed to transport coal in 1985 requires projection of the coal flow (origin-destination) matrix. The delivered cost of coal and historic distributions were used to predict this matrix.

Modal shares for 1985 were estimated to continue at 1973 levels for truck and conveyor, Great Lakes, and tidewater. At 1.2 billion tons, the unconstrained shares predicted for truck and conveyor, Great Lakes, and tidewater were 211.1, 53.5, 10.3 million tons, respectively.

Sectional river capacities were estimated by using projected lock capacities and average sectional length of haul. Each river section capacity (section length determined by average length of haul, ± one standard deviation) was constrained by the smallest capacity lock in that section.

The remaining modal shares--rail and barge movements on the inland waterways--were projected based on (1) combinations of historic shares and least cost for the unconstrained share, and (2) constrained river capacities for the three constrained shares. Projected rail movements ranged from 894 million tons for the unconstrained share to 945 million tons for constrained modal share No. 3. Section river capacities constrained the projected maximum 1985 river movements (estimated at 229,655,000 tons in the unconstrained share) from 80 to 112 million tons (constrained shares No. 1 through No. 3).

Equipment estimates were made for 1985 rail and water transportation based on average and best 1973 practice. Average practice assumes continuing 1973 average technology and equipment utilization: For rail, hopper car utilization would be 0.74 X 10^6 annual ton-miles per 100-ton hopper car, requiring 604,500 to 674,000 cars; for water, barge utilization would be 12.1 X 10^6 annual ton-miles per 1,400-ton barge, requiring 3,100 to 5,940 barges.

Best practice assumes that 1973 best technology will be 1985 average. For rail, hopper car utilization would be 3.43 X 10^6 ton-miles per 100-ton car (assuming 50 percent unit trains), requiring 125,700 to 141,600 cars; for water, use of barges would become 21.0 X 10^6 ton-miles per 1,400-ton barge, requiring 1,750 to 3,450 barges.

Average and best practice equipment estimates were compared. For rail, average practice would require four times more hopper cars; barge requirement would fall by one-third if best practice was completely implemented. Complete implementation of 1973 best practice by 1985 is unlikely.

Collateral factors possibly affecting estimates of transportation equipment are (1) development and implementation of coal conversion processes, (2) coal slurry pipeline developments, (3) air quality standards, (4) mine size distribution, (5) transportation regulation, (6) the availability of capital, and (7) uncertain futures for coal production.

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APPENDIX A.--METHODOLOGY FOR TABLE 12

The equations used for developing regional consumption are as follows:

$$PC_{1985} = (EC + IC + RCC)F + U_R C \frac{EC}{E_R C} F + C_{1985} \frac{CC_{1973}}{Cu.s.C_{1973}} ,$$

where PC_{1985} = 1985 projected State consumption.

EC = State electric utility coal consumption projected to 1980 (55, table 5).

IC = State industrial coal consumption projected to 1980 (55, table 8).

RCC = State residential/commercial coal consumption projected to 1980 (55, table 11).

$U_R C$ = Unidentified regional consumption for electric utilities in 1980 (55, table 5).

$E_R C$ = Known regional consumption for electric utilities in 1980 (55, table 5).

F = Factor of increase = $\frac{1{,}200{,}000{,}000 - C_{1985} - 1985 \text{ exports}}{670{,}837{,}000}$.

C_{1985} = Projected coking coal consumption in 1985 = 75,000,000 tons.

CC_{1973} = State coking coal consumption in 1973 (56).

$Cu.s.C_{1973}$ = Domestic coking coal consumption in 1973 (56).

Export markets were handled in the following manner:

$$EM_{1985} = EC_{1985} \frac{EM_{1973}}{EC_{1973}} ,$$

where EM_{1985} = Projected coal exported to a particular market in 1985.

EM_{1973} = Actual coal shipped to that market in 1973 (56).

EC_{1973} = Total coal exported in 1973 (56).

EC_{1985} = Total projected export coal in 1985 = 112,000,000 short tons.

The aggregation of domestic and export markets forms the regional consumption pattern.

APPENDIX B.--METHODOLOGY FOR TABLE 14

The equations utilized in the delivered cost of coal matrix are as follows:

$$\text{Rail transportation cost } (\leq 300 \text{ miles}) = 114 + 1.236X - 0.00081X^2.$$

$$\text{Rail transportation cost } (> 300 \text{ miles}) = 193 + 0.396X.$$

Cost of coal at consumption point (cents per million Btu)

$$= \frac{\text{Cost of coal per ton}}{\text{Btu content per ton}} + \frac{\text{Rail transportation cost}}{\text{Btu content per ton}}.$$

The costs were derived by--

1. Discerning the price per ton and Btu content per pound for each producer district (table B-1). The Bureau of Mines, Division of Fossil Fuels, made available the 1973 data regarding these subjects (table B-2).

2. Updating the average practice rail cost functions presented in IC 8614. This was accomplished by applying rail rate exparte information to the data base developed in that study. The preceding functions reflect a 10-percent increase over the 1971 cost formulas.

3. Applying distances from production to consumption points as estimated in the Rand McNally Railroad Guide (35).

TABLE B-1. - Bituminous coal and lignite producing districts (25)

DISTRICT 1.—EASTERN PENNSYLVANIA

Pennsylvania

Armstrong County (part).—All mines east of Allegheny River, and those mines served by the Pittsburgh & Shawmut Railroad located on the west bank of the river.

Fayette County (part).—All mines located on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.

Indiana County (part).—All mines not served by the Saltsburg branch of the Pennsylvania Railroad.

Westmoreland County (part).—All mines served by the Pennsylvania Railroad from Torrance, east.

All mines in the following counties:

Bedford
Blair
Bradford
Cambria
Cameron
Centre
Clarion
Clearfield
Clinton
Elk
Forest
Fulton
Huntingdon
Jefferson
Lycoming
McKean
Mifflin
Potter
Somerset
Tioga

Maryland.—All mines in the State.

West Virginia.—All mines in the following counties:

Grant
Mineral
Tucker

DISTRICT 2.—WESTERN PENNSYLVANIA

Pennsylvania

Armstrong County (part).—All mines west of the Allegheny River except those mines served by the Pittsburgh & Shawmut Railroad.

Fayette County (part).—All mines except those on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.

Indiana County (part).—All mines served by the Saltsburg branch of the Pennsylvania Railroad.

Westmoreland County (part).—All mines except those served by the Pennsylvania Railroad from Torrance, east.

All mines in the following counties:

Allegheny
Beaver
Butler
Greene
Lawrence
Mercer
Venango
Washington

DISTRICT 3.—NORTHERN WEST VIRGINIA

West Virginia

Nicholas County (part).—All mines served by or north of the Baltimore & Ohio Railroad.

All mines in the following counties:

Barbour
Braxton
Calhoun
Doddridge
Gilmer
Harrison
Jackson
Lewis
Marion
Monongalia
Pleasants
Preston
Randolph
Ritchie
Roane
Taylor
Tyler
Upshur
Webster
Wetzel
Wirt
Wood

DISTRICT 4.—OHIO.—All mines in the State.

DISTRICT 5.—MICHIGAN.—All mines in the State.

DISTRICT 6.—PANHANDLE

West Virginia.—All mines in the following counties:

Brooke
Hancock
Marshall
Ohio

DISTRICT 7.—SOUTHERN NO. 1

West Virginia

Fayette County (part).—All mines east of Gauley River and all mines served by the Gauley River branch of the Chesapeake & Ohio Railroad and mines served by the Virginian Railway.

McDowell County (part).—All mines in that portion of the county served by the Dry Fork branch of the Norfolk & Western Railroad and east thereof.

Raleigh County (part).—All mines except those on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.

Wyoming County (part).—All mines in that portion served by the Gilbert branch of the Virginian Railway lying east of the mouth of Skin Fork of Guyandot River and in that portion served by the main line and the Glen Rogers branch of the Virginian Railway.

All mines in the following counties:

Greenbrier
Mercer
Monroe
Pocahontas
Summers

Virginia

Buchanan County (part).—All mines in that portion of the county served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad and in that portion on the headwaters of Dismal Creek east of Lynn Camp Creek (a tributary of Dismal Creek).

Tazewell County (part).—All mines in those portions of the county served by the Dry Fork branch to Cedar Bluff and from Bluestone Junction to Boissevein branch of the Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

All mines in the following counties:

Montgomery
Pulaski
Wythe
Giles
Craig

DISTRICT 8.—SOUTHERN NO. 2

West Virginia

Fayette County (part).—All mines west of the Gauley River except mines served by the Gauley River branch of the Chesapeake & Ohio Railroad.

McDowell County (part).—All mines west of and not served by the Dry Fork branch of the Norfolk & Western Railroad.

Nicholas County (part).—All mines in that part of the county south of and not served by the Baltimore & Ohio Railroad.

Raleigh County (part).—All mines on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.

Wyoming County (part).—All mines in that portion served by the Gilbert branch of the Virginian Railway and lying west of the mouth of Skin Fork of Guyandot River.

All mines in the following counties:

Boone
Cabell
Clay
Kanawha
Lincoln
Logan
Mason
Mingo
Putnam
Wayne

Virginia

Buchanan County (part).—All mines in the county, except in that portion on the headwaters of Dismal Creek, east of Lynn Camp Creek (a tributary of Dismal Creek) and in that portion served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

Tazewell County (part).—All mines in the county except in those portions served by the Dry Fork branch of the Norfolk & Western Railroad and branch from Bluestone Junction to Boissevain of Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

All mines in the following counties:

Dickinson
Lee
Russell
Scott
Wise

Kentucky.—All mines in the following counties in eastern Kentucky:

Bell
Boyd
Breathitt
Carter
Clay
Elliott
Floyd
Greenup
Harlan
Jackson
Johnson
Knott
Knox
Laurel
Lawrence
Lee
Leslie
Letcher
McCreary
Magoffin
Martin
Morgan
Owsley
Perry
Pike
Rockcastle
Wayne
Whitley

Tennessee.—All mines in the following counties:

Anderson
Campbell
Claiborne
Cumberland
Fentress
Morgan
Overton
Putnam,
Roane
Scott

North Carolina.—All mines in the State.

DISTRICT 9.—WEST KENTUCKY

Kentucky.—All mines in the following counties in western Kentucky:

Butler
Christian
Crittenden
Daviess
Hancock
Henderson
Hopkins
Logan
McLeen
Muhlenberg
Ohio
Simpson
Todd
Union
Warren
Webster

DISTRICT 10.—ILLINOIS.—All mines in the State.

DISTRICT 11.—INDIANA.—All mines in the State.

DISTRICT 12.—IOWA.—All mines in the State.

DISTRICT 13.—SOUTHEASTERN

Alabama.—All mines in the State.

Georgia.—All mines in the following counties:

Dade
Walker

Tennessee.—All mines in the following counties:

Bledsoe
Grundy
Hamilton
Marion
McMinn
Rhea
Sequatchie
Van Buren
Warren
White

DISTRICT 14.—ARKANSAS-OKLAHOMA

Arkansas.—All mines in the State.

Oklahoma.—All mines in the following counties:

Haskell
Le Flore
Sequoyah

DISTRICT 15.—SOUTHWESTERN

Kansas.—All mines in the State.

Missouri.—All mines in the State.

Oklahoma.—All mines in the following counties:

Coal
Craig
Latimer
Muskogee
Okmulgee
Pittsburg
Rogers
Tulsa
Wagoner

DISTRICT 16.—NORTHERN COLORADO

All mines in the following counties in the State:

Adams
Arapahoe
Boulder
Douglas
Elbert
El Paso
Jackson
Jefferson
Larimer
Weld

DISTRICT 17.—SOUTHERN COLORADO

Colorado.—All mines except those included in District 16.

New Mexico.—All mines except those included in District 18.

DISTRICT 18.—NEW MEXICO

New Mexico.—All mines in the following counties:

Grant
Lincoln
McKinley
Rio Arriba
Sandoval
San Juan
San Miguel
Santa Fe
Socorro

Arizona.—All mines in the State.

California.—All mines in the State.

DISTRICT 19.—WYOMING

Wyoming.—All mines in the State.

Idaho.—All mines in the State.

DISTRICT 20.—UTAH.—All mines in the State.

DISTRICT 21.—NORTH DAKOTA-SOUTH DAKOTA.—

All mines in North Dakota and South Dakota.

DISTRICT 22.—MONTANA.—All mines in the State.

DISTRICT 23.—WASHINGTON

Washington.—All mines in the State.

Oregon.—All mines in the State.

Alaska.—All mines in the State.

TABLE B-2. - Btu content and value at bituminous coal and lignite mines in the United States, by district

	District	Average Btu per pound of coal (dry)[1]	Average value per ton, 1973[2]
1	Eastern Pennsylvania	13,612	$9.27
2	Western Pennsylvania	13,336	11.42
3	Northern West Virginia	13,496	9.03
4	Ohio	12,234	7.40
5	Michigan	-	-
6	Panhandle	12,762	8.86
7	Southern Numbered 1	14,040	15.73
8	Southern Numbered 2	13,663	10.08
9	West Kentucky	12,285	5.93
10	Illinois	11,400	6.71
11	Indiana	11,490	6.06
12	Iowa	9,900	5.46
13	Southeastern	13,368	10.88
14	Arkansas-Oklahoma	12,293	13.61
15	Southwestern	12,615	4.41
16	Northern Colorado	9,431	5.17
17	Southern Colorado	11,875	7.89
18	New Mexico	11,749	2.83
19	Wyoming	10,860	4.09
20	Utah	12,610	11.19
21	North Dakota-South Dakota	6,837	2.07
22	Montana	10,280	2.82
23	Washington	10,056	7.08

[1] BuMines IC 8614 (25).

[2] BuMines, Division of Fossil Fuels.

APPENDIX C.--METHODOLOGY FOR TABLES 15-16

After the historic distribution was proportionally increased (table 15), the following process was instituted:

1. Columnar summation was performed to establish the amount of supply requested from a producer district.

2. The supply requested from each district was compared with estimates of district production capability in 1985 (table C-1).

3. Districts were classified as to their ability to fulfill the supply requested in the expansion of historic coal distribution. Those having a resultant oversupply were listed as the alternate sources of coal production.

4. Regions (States) of consumption identified as the major cause of undersupply in the remaining districts were listed, and delivered costs to the alternate sources of supply were assigned.

5. A least-cost method of balancing regions of consumption with sources of production was conducted as outlined in the publication "Toward the Selection of Optimal Transport Assignments: The Transportation Algorithm" (6). The result is table 16.

TABLE C-1. - Estimated coal supply, by methods of mining, supply areas, and coal producing districts in 1985

(Thousand short tons)

Coal supply areas by districts	1985				
		Surface			
	Under-ground	Strip	Auger	Total surface	Total
I. Northern Appalachia:					
1. Eastern Pennsylvania	30,760	33,955	700	34,655	65,415
2. Western Pennsylvania	42,860	13,900	265	14,165	57,025
3. Northern West Virginia	39,120	14,370	415	14,785	53,905
6. Panhandle West Virginia	12,840	350	10	360	13,200
Total Districts 3 and 6	51,960	14,720	425	15,145	67,105
4. Ohio	23,740	53,305	1,010	54,315	78,055
5. Michigan	-	-	-	-	-
Total Northern Appalachia	149,320	115,880	2,400	118,280	267,600
Percent of total	55.8	43.3	0.9	44.2	100.0
II. Southern Appalachia:					
7. Southern Numbered 1	48,095	7,355	755	8,110	56,205
8. Southern Numbered 2	190,595	83,575	26,100	109,675	300,270
13. Southeastern	15,775	29,670	80	29,750	45,525
Total Southern Appalachia	254,465	120,600	26,935	146,535	402,000
Percent of total	63.3	30.0	6.7	36.7	100.0
III. Midwestern:					
9. West Kentucky	28,140	58,040	245	58,285	86,425
10. Illinois	42,870	54,430	-	54,430	97,300
11. Indiana	2,220	42,755	-	42,755	44,975
12. Iowa	665	1,030	-	1,030	1,695
14. Arkansas-Oklahoma	150	1,375	-	1,375	1,525
15. Southwestern	-	14,080	-	14,080	14,080
Total Midwestern	74,045	171,710	245	171,955	246,000
Percent of total	30.0	69.8	0.2	70.0	100.0
IV. Gulf:					
13. Southeastern	-	-	-	-	-
15. Southwestern	-	43,200	-	43,200	43,200
Total Gulf	-	43,200	-	43,200	43,200
Percent of total	-	100.0	-	100.0	100.0
V. Northern Great Plains:					
19. Wyoming	3,435	85,050	-	85,050	88,485
21. North-South Dakota	-	35,095	-	35,095	35,095
22. Montana	95	52,725	-	52,725	52,820
Total Northern Great Plains	3,530	172,870	-	172,870	176,400
Percent of total	2.0	98.0	-	98.0	100.0
VI. Rocky Mountain:					
16. Northern Colorado	1,250	-	-	-	1,250
17. Southern Colorado	7,340	5,160	-	5,160	12,500
18. New Mexico	-	22,535	-	22,535	22,535
20. Utah	8,060	55	-	55	8,115
Total Rocky Mountain	16,650	27,750	-	27,750	44,400
Percent of total	37.5	62.5	-	62.5	100.0
VII. Pacific Coast:					
18. New Mexico	-	-	-	-	-
23. Washington	185	20,215	-	20,215	20,400
Total Pacific Coast	185	20,215	-	20,215	20,400
Percent of total	0.3	99.7	-	99.7	100.0
Total United States	498,195	672,225	29,580	701,805	1,200,000
Percent of total	41.5	56.0	2.5	58.5	100.0

Source: Project Independence Blueprint (16).

APPENDIX D.--METHODOLOGY FOR FIGURE 9

Sectionalization and practical capacity estimates for selected rivers were attained in the following manner:

1. Corps of Engineers' estimates of practical capacity are assigned to the locks of the river in question. The low and high estimates are comprised of 1980 and 1990 capacity projections, respectively (table D-1).

2. One standard deviation above the mean is established as the high boundary for length of coal haul on that river. One below is established as the low boundary.

3. The river system is then sectionalized according to which boundary (high-low) is chosen. Sectionalization is used because origin-destination points are aggregate areas, and actual river distances are not accurately represented. The constricting (lowest tonnage) lock in each section is identified as the capacity of that section. This assumes 100 percent coal traffic and gives maximum-minimum capacity results.

4. The sectionalization process is repeated using different starting points. This is done to maximize the aggregate capacity for that river system by grouping the greatest number of restricting locks in each section.

5. Processes 1-4 are repeated for each boundary length of haul and river system.

TABLE D-1. - Projected practical capacities for locks on the Ohio, Monongahela, Kanawha, Green, and Illinois Rivers

	Capacity, Million short tons		Miles above mouth
	1980	1990	
Ohio River:			
Emsworth	27	33	974
Dashields	30	34	967
Montgomery	28	38	948
New Cumberland	31	41	926
Pike Island	34	47	896
Hannibal	35	50	854
Willow Island	39	54	818
Belleville	41	57	776
Racine	41	58	742
Gallipolis	45	66	701
Greenup	48	68	639
Meldahl	50	69	544
Markland	49	64	448
McAlpine	60	81	373
Cannelton	61	83	259
Newburgh	55	69	204
Uniontown	62	83	134
Smithland	75	99	61
Fifty-two (52)	79	99	41
Fifty-three (53)	79	103	17
Mound City	79	103	6
Monongahela River:			
Mon. 2	23	25	11
Mon. 3	24	25	24
Mon. 4	22	23	42
Maxwell	22	23	61
Mon. 7	13	17	85
Mon. 8	13	17	91
Kanawha River:			
Winfield	16	19	33
Marmet	10	13	68
London	6	9	82
Green River:			
No. 1	28	35	60
No. 2	28	35	105
Illinois River:			
LaGrange	37.9	49.2	80
Peoria	40.1	51.9	158
Starved Rock	31.8	41.8	231
Marseilles	30.8	41.0	245
Dresden Island	33.2	42.1	271
Brandon Road	30.6	37.9	286
Lockport	32.0	37.5	291

APPENDIX E.--METHODOLOGY FOR CONSTRAINED WATER SHIPMENTS OF COAL

Coal tonnages projected to move between listed origin-destination were reduced to river section capacity in the following manner:

1. The tributaries are the first to be analyzed and are balanced in progressive sections from headwater to mouth.[1] [2]

2. The first section is balanced by unilaterally reducing the projected tonnages of the origin-destinations traversing the section by a constant percentage. This percentage is dictated by the amount of reduction necessary to reach rated capacity.

3. The next section down the river can only be balanced by reducing the amount of coal originating or terminating in its section. (Coal balanced on section 1 cannot be balanced again on section 2.) This process is repeated down the river until all sections have been reduced to capacity.

4. After coal traffic on all tributaries has been reduced to the rated capacity, the main river is balanced in the same manner progressing from its headwater area to its mouth. (Coal traffic that has already been reduced on a tributary cannot be reduced on the main river.)

5. Steps 1-4 are repeated for each of the four minimum sectional capacity configurations of the three river systems chosen.[3] Tables E-1--E-3 depict the results of the process.

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[1] Assumption is that once the tonnage is on the river, it will not be removed.

[2] The reduction of the tributary will lead to a reduction of the overtaxed main river.

[3] The Illinois River was not analyzed on an individual basis since the projected coal tonnages did not exceed projected sectional capacity on that river.

TABLE E-1. - Projected 1985 origin-destination coal tonnage on the Ohio River

(Thousand short tons)

Origin-destination	Projected sectional tonnages													
	Section 1		Section 2		Section 3		Section 4		Section 5		Section 6		Section 7	
	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity
LOW BOUNDARY LENGTH OF HAUL = 82 MILES														
District 2:														
Indiana.......	-	-	-	-	-	-	-	-	-	-	876	840	876	840
Ohio..........	-	-	-	-	-	-	-	-	-	-	-	-	3,619	3,456
Pennsylvania..	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Virginia.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 4:														
Ohio..........	-	-	-	-	-	-	-	-	-	-	-	-	28,438	19,679
West Virginia.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 6:														
West Virginia.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 7:														
Indiana.......	-	-	-	-	-	-	-	-	-	-	4,514	3,009	4,514	3,009
Louisiana.....	19	12	19	12	19	12	19	12	19	12	19	12	19	12
Mississippi...	38	26	38	26	38	26	38	26	38	26	38	26	38	26
Ohio..........	-	-	-	-	-	-	-	-	-	-	-	-	1,206	804
Pennsylvania..	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 8:														
Indiana.......	-	-	-	-	-	-	-	-	-	-	3,863	2,661	3,863	2,661
Louisiana.....	95	65	95	65	95	65	95	65	95	65	95	65	95	65
Ohio..........	-	-	-	-	-	-	-	-	-	-	-	-	25,330	17,448
Pennsylvania..	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Virginia.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 9:														
Florida.......	2,779	2,223	2,779	2,223	2,779	2,223	2,779	2,223	-	-	-	-	-	-
Illinois......	1,444	1,155	1,444	1,155	1,444	1,155	-	-	-	-	-	-	-	-
Indiana.......	-	-	-	-	-	-	5,524	4,419	5,524	4,419	5,524	4,419	-	-
Iowa..........	870	696	870	696	870	696	870	696	-	-	-	-	-	-
Kentucky......	-	-	-	-	-	-	11,007	8,806	11,007	8,806	11,007	8,806	-	-
Minnesota.....	481	385	481	385	481	385	481	385	-	-	-	-	-	-
Mississippi...	538	431	538	431	538	431	538	431	-	-	-	-	-	-
Missouri......	312	250	312	250	312	250	312	250	-	-	-	-	-	-
Tennessee.....	-	-	12,040	9,632	12,040	9,632	12,040	9,632	-	-	-	-	-	-
District 11:														
Tennessee.....	800	800	800	800	-	-	-	-	-	-	-	-	-	-
Total......	7,376	6,043	19,416	15,675	18,616	14,875	35,147	28,100	16,683	13,328	25,936	19,838	67,998	48,000

TABLE E-1. - Projected 1985 origin-destination coal tonnage on the Ohio River--Continued

(Thousand short tons)

Origin-destination	Projected sectional tonnages													
	Section 8		Section 9		Section 10		Section 11		Section 12		Section 13		Section 14	
	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity
	LOW BOUNDARY LENGTH OF HAUL = 82 MILES--Continued													
District 2:														
Indiana.......	876	840	876	840	876	840	876	840	876	840	876	840	876	840
Ohio..........	3,619	3,456	3,619	3,456	3,619	3,456	3,619	3,456	3,619	3,456	3,619	3,456	3,619	3,456
Pennsylvania..	-	-	-	-	-	-	-	-	-	-	10,990	10,484	10,990	10,484
West Virginia.	-	-	-	-	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446	1,446
District 4:														
Ohio..........	28,438	19,679	28,438	19,679	28,438	19,679	28,438	19,679	28,438	19,679	-	-	-	-
West Virginia.	-	-	-	-	586	586	586	586	586	586	-	-	-	-
District 6:														
West Virginia.	-	-	-	-	1,220	1,220	1,220	1,220	1,220	1,220	-	-	-	-
District 7:														
Indiana.......	4,514	3,009	4,514	3,009	4,514	3,009	-	-	-	-	-	-	-	-
Louisiana.....	19	12	19	12	19	12	-	-	-	-	-	-	-	-
Mississippi...	38	26	38	26	38	26	-	-	-	-	-	-	-	-
Ohio..........	1,206	804	1,206	804	1,206	804	-	-	-	-	-	-	-	-
Pennsylvania..	-	-	-	-	3,222	2,148	3,222	2,148	3,222	2,148	3,222	2,148	-	-
District 8:														
Indiana.......	3,863	2,661	3,863	2,661	-	-	-	-	-	-	-	-	-	-
Louisiana.....	95	65	95	65	-	-	-	-	-	-	-	-	-	-
Ohio..........	25,330	17,448	25,330	17,448	-	-	-	-	-	-	-	-	-	-
Pennsylvania..	-	-	-	-	4,845	4,625	4,845	4,625	4,845	4,625	4,845	4,625	-	-
West Virginia.	-	-	-	-	6,747	6,747	-	-	-	-	-	-	-	-
District 9:														
Florida.......	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Illinois......	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indiana.......	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iowa..........	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kentucky......	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Minnesota.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mississippi...	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Missouri......	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tennessee.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District 11:														
Tennessee.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total......	67,998	48,000	67,998	48,000	67,998	44,598	56,719	34,000	44,252	34,000	24,998	22,999	16,931	16,226

TABLE E-1. - Projected 1985 origin-destination coal tonnage on the Ohio River--Continued

(Thousand short tons)

Origin-destination	Projected sectional tonnages									
	Section 1		Section 2		Section 3		Section 4		Section 5	
	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity	High capacity	Low capacity
	HIGH BOUNDARY LENGTH OF HAUL = 322 MILES									
District 2:										
Indiana.......	-	-	-	-	367	290	367	290	367	290
Ohio..........	-	-	-	-	1,523	1,195	1,523	1,195	1,523	1,195
Pennsylvania..	-	-	-	-	-	-	4,621	3,631	4,621	3,631
West Virginia.	-	-	-	-	-	-	1,446	1,446	1,446	1,446
District 4:										
Ohio..........	-	-	-	-	5,454	4,286	5,454	4,286	-	-
West Virginia.	-	-	-	-	-	-	586	586	-	-
District 6:										
West Virginia.	-	-	-	-	-	-	1,220	1,220	-	-
District 7:										
Indiana.......	-	-	-	-	4,514	3,009	4,514	3,009	-	-
Louisiana.....	19	12	19	12	19	12	19	12	-	-
Mississippi...	38	26	38	26	38	26	38	26	-	-
Ohio..........	-	-	-	-	1,206	804	1,206	804	-	-
Pennsylvania..	-	-	-	-	-	-	3,222	2,148	3,222	2,148
District 8:										
Indiana.......	-	-	-	-	4,168	2,428	-	-	-	-
Louisiana.....	102	59	102	59	102	59	-	-	-	-
Ohio..........	-	-	-	-	27,331	15,919	-	-	-	-
Pennsylvania..	-	-	-	-	-	-	2,037	1,600	2,037	1,600
West Virginia.	-	-	-	-	6,747	6,747	6,747	6,747	-	-
District 9:										
Florida.......	2,779	2,223	2,779	2,223	-	-	-	-	-	-
Illinois......	1,444	1,155	1,444	1,155	-	-	-	-	-	-
Indiana.......	-	-	5,524	4,419	5,524	4,419	-	-	-	-
Iowa..........	870	696	870	696	-	-	-	-	-	-
Kentucky......	-	-	11,007	8,806	11,007	8,806	-	-	-	-
Minnesota.....	481	385	481	385	-	-	-	-	-	-
Mississippi...	538	431	538	431	-	-	-	-	-	-
Missouri......	312	250	312	250	-	-	-	-	-	-
Tennessee.....	-	-	12,040	9,632	-	-	-	-	-	-
District 11:										
Tennessee.....	-	-	800	800	-	-	-	-	-	-
Total......	7,121	5,237	36,492	28,894	68,000	48,000	33,000	27,000	13,216	11,215

TABLE E-2. - Projected 1985 origin-destination coal tonnage on the Kanawha River

(Thousand short tons)

Origin-destination	Projected sectional tonnages			
	Section 1		Section 2	
	High capacity	Low capacity	High capacity	Low capacity
LOW BOUNDARY LENGTH OF HAUL = 56 MILES				
District 2: West Virginia...........	1,446	1,446	-	-
District 4: West Virginia...........	586	586	-	-
District 6: West Virginia...........	1,220	1,220	-	-
District 7:				
Indiana...........	4,514	3,009	4,514	3,009
Louisiana.........	19	12	19	12
Mississippi.......	38	26	38	26
Ohio..............	1,206	804	1,206	804
Pennsylvania......	3,222	2,148	3,222	2,148
District 8: West Virginia...........	6,747	6,747	-	-
Total.........	18,998	15,998	8,999	5,999
HIGH BOUNDARY LENGTH OF HAUL = 72 MILES				
District 2: West Virginia...........	1,446	1,446	-	-
District 4: West Virginia...........	586	586	-	-
District 6: West Virginia...........	1,220	1,220	-	-
District 7:				
Indiana...........	4,514	3,009	4,514	3,009
Louisiana.........	19	12	19	12
Mississippi.......	38	26	38	26
Ohio..............	1,206	804	1,206	804
Pennsylvania......	3,222	2,148	3,222	2,148
District 8: West Virginia...........	6,747	6,747	-	-
Total.........	18,998	15,998	8,999	5,999

TABLE E-3. - Projected 1985 origin-destination coal tonnage on the Green River (average length of haul = 98 miles)

(Thousand short tons)

Origin-destination	Projected sectional tonnages in section 1	
	High capacity	Low capacity
District 9:		
Florida	2,779	2,223
Illinois	1,444	1,155
Indiana	5,524	4,419
Iowa	870	696
Kentucky	11,007	8,806
Minnesota	481	385
Mississippi	538	431
Missouri	312	250
Tennessee	12,040	9,632
Total	34,995	27,997

APPENDIX F.--METHODOLOGY FOR TABLE 26

Equipment requirements for water transportation of coal were estimated as follows:

1. The rivers to be traveled between an origin-destination determined the maximum number of barges per tow, size of barges used, and average speeds (table F-1).

2. Each origin-destination routing was assigned a round trip transit time based on the speeds attainable on the rivers comprising the route in conjunction with a standard loading/unloading time.

3. Barge requirements between each origin-destination were estimated in the following manner:

$$\frac{\text{7,200 hours[1]}}{\begin{array}{c}\text{Round trip transit}\\ \text{time (hours)}\end{array}} \times \frac{\text{Annual tonnage}}{\begin{array}{c}\text{Capacity per tow}\\ \text{(tons)}\end{array}} \times \begin{array}{c}\text{Maximum number of}\\ \text{barges per tow}\end{array}$$

$$= \text{Number of barges required per origin-destination.}$$

4. Total barge requirements per modal share were obtained by summing the origin-destinations comprising that share.

5. Towboats were obtained by assigning one power unit to each tow required.

Equipment requirements for rail transportation of coal were estimated as follows:

1. Individual ton-miles for each origin-destination are summed.

2. The origin-destinations generating the largest amount of ton-miles are summed to represent unit train operations. The break in ton-miles is selected so that about one-half the rail tonnage is moved by unit train.

3. The ton-miles of the remaining origin-destinations are summed to represent multiple car loading. The logic is that the distribution of micro consumers and producers will require some single and multiple car operations due to the small scale of operations.

4. The best practice unit train ton-miles are calculated by assuming--

   a. 20 miles per hour train speed (or 10 miles per hour loaded),

   b. 7,200-hour year (300 days) estimated operating time in 1 year, and

---

[1] An estimation of operating time realized in 1 year.

c. 100-ton cars.

Best practice car ton-miles = 10 miles per hour X 7,200 hours X 100 tons per car = 7.2×10^6.

5. Multiple car annual ton-miles are based on an average loaded speed of 2.5 miles per hour.

Multiple car annual ton-miles = 2.5 miles per hour X 7,200 hours per year X 100 tons per car = 1.8×10^6.

TABLE F-1. - Operational capacities of the major coal hauling waterways[1]

Waterway	Maximum number of barges per tow: Standard barges (175 feet by 26 feet, 900 tons)	Maximum number of barges per tow: Jumbo barges (195 feet by 35 feet, 1,400 tons)	Average speeds (including lock time), mi/hr
Alabama rivers[2].................	-	4	6.67 downstream 4.58 upstream
Arkansas River..................	-	6	5.28 downstream 3.53 upstream
Green River.....................	-	15	5.63 downstream 4.09 upstream
Gulf Intracoastal Waterway:			
West of New Orleans, La........	10	5	[3]7.92
East of New Orleans, La........	-	2	[3]8.33
Illinois Waterway...............	-	15	[3]4.09
Kanawha River...................	10	-	5.70 downstream 4.28 upstream
Mississippi River:			
Minneapolis, Minn.-St. Louis, Mo............................	-	15	[3]4.17
St. Louis, Mo.-Cairo, Ill......	-	30	8.33 downstream 5.00 upstream
Cairo, ill.-Gulf of Mexico.......	-	40	8.33 downstream 5.00 upstream
Ohio River......................	20	15	[3]4.17
Tennessee River.................	-	24	[3]4.17

[1] Based on water carrier interviews and the Barge Mixing Rule (60).

[2] Includes Black Warrior and Tombigbee Rivers.

[3] Speed is average regardless of direction.

APPENDIX G.--PROJECTED 1985 MODAL SHARES

TABLE G-1. - Bituminous coal and lignite distribution for 1985 according to the unconstrained modal share analysis

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Alabama:																				
Rail	-	-	-	-	923	1,789	5,020	2,237	-	-	28,094	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	10,689	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	923	1,789	5,020	2,237	-	-	38,783	-	-	-	-	-	-	-	-	-
Arizona: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Arkansas:																				
Rail	-	-	-	-	117	527	-	-	-	-	78	-	7,794	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	-	264	-	-	-	-	-	-	-	-
Total	-	-	-	-	117	527	-	-	-	-	78	264	7,794	-	-	-	-	-	-	-
Colorado:																				
Rail	97	-	-	-	32	68	-	-	-	-	-	-	-	509	8,712	-	6,233	-	2,191	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	741	2,427	-	-	-	-	-
Total	97	-	-	-	32	68	-	-	-	-	-	-	-	1,250	11,139	-	6,233	-	2,191	-
Delaware: Rail	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dist. of Columbia: Rail	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Florida:																				
Rail	-	-	-	-	-	4,398	-	507	1,048	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	4,338	-	-	-	949	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	4,398	4,338	507	1,048	-	949	-	-	-	-	-	-	-	-	-
Georgia: Rail	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Idaho:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	37	-	488
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	175	-	488
Illinois:																				
Rail	-	-	32	-	924	4,854	-	44,372	246	-	-	125	-	-	37	-	-	-	1,059	-
Water	-	-	-	-	-	-	2,254	-	-	-	-	-	-	-	-	-	-	-	-	[1]11,437
Truck	-	-	-	-	-	-	-	9,767	545	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	32	-	924	4,854	2,254	54,139	791	-	-	125	-	-	37	-	-	-	1,059	11,437
Indiana:																				
Rail	871	-	-	10	-	[2]6,843	-	11,406	25,841	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Water	-	1,921	-	-	7,044	5,581	8,623	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	50	10,730	-	-	-	-	-	-	-	-	-	-	-
Total	871	1,921	-	10	7,044	12,424	8,623	11,456	36,571	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Iowa:																				
Rail	-	-	-	-	122	28	-	-	46	587	-	-	313	-	35	-	3,253	-	673	8,071
Water	-	-	-	-	-	-	1,358	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	1,108	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	122	28	1,358	-	46	1,695	-	-	313	-	35	-	3,253	-	673	8,071
Kansas: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Kentucky:																				
Rail	-	-	62	-	345	13,018	-	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	12,139	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	736	17,183	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	62	-	345	13,754	29,322	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Louisiana:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	69	2,038	-	-	-	-	-	-	-
Water	-	-	-	-	29	137	-	-	-	-	20	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	29	137	-	-	-	-	20	69	2,038	-	-	-	-	-	-	-
Maryland:																				
Rail	6,024	-	1,053	-	251	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	1,516	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tidewater	1,448	151	913	-	912	6,878	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8,988	151	1,966	-	1,163	7,381	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Massachusetts: Rail	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan:																				
Rail	-	-	5,917	16,884	291	6,953	1,152	99	8	-	-	-	-	-	-	-	-	-	2,311	231
Great Lakes	-	270	3,198	4,657	2,673	12,475	1,802	1,993	625	-	-	-	-	-	-	-	-	-	-	-
Total	-	270	9,115	21,541	2,964	19,428	2,954	2,092	633	-	-	-	-	-	-	-	-	-	2,311	231
Minnesota:																				
Rail	-	-	-	-	-	389	-	-	-	-	-	-	23	-	-	-	225	-	2,938	8,007
Water	-	-	-	-	-	-	751	3,393	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	85	32	451	2,409	-	215	559	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	85	32	451	2,798	751	3,608	559	-	-	-	23	-	-	-	225	-	2,938	8,007

See footnotes at end of table.

TABLE G-1. - Bituminous coal and lignite distribution for 1985 according to the unconstrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Mississippi:																				
Rail	-	-	-	-	-	116	-	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	60	-	840	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	60	116	840	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Missouri:																				
Rail	-	-	-	-	404	1,341	-	13,484	-	-	140	-	5,523	-	26	-	6,616	-	-	-
Water	-	-	-	-	-	-	487	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	814	-	-	-	-	5,441	-	-	-	-	-	-	-
Total	-	-	-	-	404	1,341	487	14,298	-	-	140	-	10,964	-	26	-	6,616	-	-	-
Montana:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,460
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,561
Nebraska: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Nevada:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,993
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,312	-	-
Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[3]4,800	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-	2,312	-	4,993
New Hampshire: Rail	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey: Rail	[4]874	-	[4]527	4	[4]95	[4]340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	874	-	527	4	95	340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	-	4,958	-	-	4,800
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,799	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	6,799	4,958	-	-	4,800
New York:																				
Rail	5,669	3,840	4,104	137	149	3,317	-	-	-	-	-	-	-	-	-	-	-	102	-	-
Truck	1,630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	10	-	-	-	-	213	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	7,309	3,840	4,104	137	149	3,530	-	-	-	-	-	-	-	-	-	-	-	102	-	-
North Carolina:																				
Rail	-	-	39	-	931	44,212	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	39	-	931	44,243	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota:																				
Rail	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	1,317	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,266	-
Total	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	3,583	-
Ohio:																				
Rail	-	-	4,936	-	[2]2,431	[2]14,592	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Water	-	7,935	-	28,438	1,881	36,593	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	1,244	-	23,814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	7	63	227	986	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	9,179	4,943	52,315	4,539	52,171	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Oklahoma:																				
Rail	-	-	-	-	249	633	-	-	-	-	107	219	6,671	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	2,376	-	-	-	-	-	-	-
Total	-	-	-	-	249	633	-	-	-	-	107	219	9,047	-	-	-	-	-	-	-
Oregon: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Pennsylvania:																				
Rail	16,964	-	13,824	165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	24,096	-	-	5,028	10,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	23,101	9,214	-	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	40,065	33,310	13,824	278	5,028	10,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Carolina: Rail	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota: Rail	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Total	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Tennessee:																				
Rail	-	-	-	-	184	11,951	-	1,436	-	-	13	-	62	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	18,795	-	800	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	3,548	49	-	-	-	379	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	184	15,499	18,844	1,436	800	-	392	-	62	-	-	-	-	-	-	-
Texas:																				
Rail	-	-	-	-	780	3,452	-	-	-	-	-	-	27,039	-	-	-	24,848	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	536	523	-	-	-	-	-	-	-	-
Total	-	-	-	-	780	3,452	-	-	-	-	536	523	27,039	-	-	-	24,848	-	-	-

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See footnotes at end of table.

TABLE G-1. - Bituminous coal and lignite distribution for 1985 according to the unconstrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Utah:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	354	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,974	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	3,328	-	-
Virginia:																				
Rail	11	-	-	-	701	11,328	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	26	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	-	-	-	727	11,464	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[5]3,629
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	3,629
West Virginia:																				
Rail	-	-	3,552	-	4,737	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	4,741	3,999	1,922	-	22,120	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	563	12,447	705	70	1,840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	5,304	19,998	2,627	4,807	23,960	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin:																				
Rail	-	-	-	-	-	601	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Great Lakes	648	-	520	601	245	3,870	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	648	-	520	601	245	4,471	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Wyoming:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,968	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15,274	-	-	-
Canada:																				
Rail	20	-	12	27	88	8,365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	1,681	3,027	7,184	480	2,051	106	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,701	3,027	7,196	507	2,139	8,471	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Mexico: Rail	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Other export: Rail	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Adjusted to provide water service to electric utilities not equipped for rail delivery.

[2] Adjusted to provide rail service to coking centers not reachable by water.

[3] Estimated pipeline capacity.

[4] Tidewater portion included in rail values.

[5] Actual conveyor operation.

TABLE G-2. - Bituminous coal and lignite distribution for 1985 according to the No. 1 constrained modal share analysis

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Alabama:																				
Rail	-	-	-	-	923	1,789	5,020	2,237	-	-	28,094	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	10,689	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	923	1,789	5,020	2,237	-	-	38,783	-	-	-	-	-	-	-	-	-
Arizona: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Arkansas:																				
Rail	-	-	-	-	117	527	-	-	-	-	78	-	7,794	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	-	264	-	-	-	-	-	-	-	-
Total	-	-	-	-	117	527	-	-	-	-	78	264	7,794	-	-	-	-	-	-	-
Colorado:																				
Rail	97	-	-	-	32	68	-	-	-	-	-	-	-	509	8,712	-	6,233	-	2,191	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	741	2,427	-	-	-	-	-
Total	97	-	-	-	32	68	-	-	-	-	-	-	-	1,250	11,139	-	6,233	-	2,191	-
Delaware: Rail	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dist. of Columbia: Rail	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Florida:																				
Rail	-	-	-	-	-	4,398	1,559	507	1,048	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	2,779	-	-	-	949	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	4,398	4,338	507	1,048	-	949	-	-	-	-	-	-	-	-	-
Georgia: Rail	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Idaho:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	37	-	488
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	175	-	488
Illinois:																				
Rail	-	-	32	-	924	4,854	810	44,372	246	-	-	125	-	-	37	-	-	-	1,059	-
Water	-	-	-	-	-	-	1,444	-	-	-	-	-	-	-	-	-	-	-	-	[1]11,437
Truck	-	-	-	-	-	-	-	9,767	545	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	32	-	924	4,854	2,254	54,139	791	-	-	125	-	-	37	-	-	-	1,059	11,437
Indiana:																				
Rail	871	1,045	-	10	2,530	8,561	3,099	11,406	25,841	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Water	-	876	-	-	4,514	3,863	5,524	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	50	10,730	-	-	-	-	-	-	-	-	-	-	-
Total	871	1,921	-	10	7,044	12,424	8,623	11,456	36,571	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Iowa:																				
Rail	-	-	-	-	122	28	488	-	46	587	-	-	313	-	35	-	3,253	-	673	8,071
Water	-	-	-	-	-	-	870	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	1,108	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	122	28	1,358	-	46	1,695	-	-	313	-	35	-	3,253	-	673	8,071
Kansas: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Kentucky:																				
Rail	-	-	62	-	345	13,018	1,132	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	11,007	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	736	17,183	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	62	-	345	13,754	29,322	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Louisiana:																				
Rail	-	-	-	-	10	42	-	-	-	-	-	69	2,038	-	-	-	-	-	-	-
Water	-	-	-	-	19	95	-	-	-	-	20	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	29	137	-	-	-	-	20	69	2,038	-	-	-	-	-	-	-
Maryland:																				
Rail	6,024	-	1,053	-	251	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	1,516	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tidewater	1,448	151	913	-	912	6,878	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8,988	151	1,966	-	1,163	7,381	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Massachusetts: Rail	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan:																				
Rail	-	-	5,917	16,884	291	6,953	1,152	99	8	-	-	-	-	-	-	-	-	-	2,311	231
Great Lakes	-	270	3,198	4,657	2,673	12,475	1,802	1,993	625	-	-	-	-	-	-	-	-	-	-	-
Total	-	270	9,115	21,541	2,964	19,428	2,954	2,092	633	-	-	-	-	-	-	-	-	-	2,311	231
Minnesota:																				
Rail	-	-	-	-	-	389	270	-	-	-	-	-	23	-	-	-	225	-	2,938	8,007
Water	-	-	-	-	-	-	481	3,393	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	85	32	451	2,409	-	215	559	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	85	32	451	2,798	751	3,608	559	-	-	-	23	-	-	-	225	-	2,938	8,007

See footnotes at end of table.

TABLE G-2. - Bituminous coal and lignite distribution for 1985 according to the No. 1 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Mississippi:																				
Rail	-	-	-	-	22	116	302	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	38	-	538	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	60	116	840	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Missouri:																				
Rail	-	-	-	-	404	1,341	175	13,484	-	-	140	-	5,523	-	26	-	6,616	-	-	-
Water	-	-	-	-	-	-	312	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	814	-	-	-	-	5,441	-	-	-	-	-	-	-
Total	-	-	-	-	404	1,341	487	14,298	-	-	140	-	10,964	-	26	-	6,616	-	-	-
Montana:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,460
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,561
Nebraska: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Nevada:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,993
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,312	-	-
Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[2]4,800	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-	2,312	-	4,993
New Hampshire: Rail	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey: Rail	[3]874	-	[3]527	4	[3]95	[3]340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	874	-	527	4	95	340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	-	4,958	-	-	4,800
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,799	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	6,799	4,958	-	-	4,800
New York:																				
Rail	5,669	3,840	4,104	137	149	3,317	-	-	-	-	-	-	-	-	-	-	-	102	-	-
Truck	1,630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	10	-	-	-	-	213	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	7,309	3,840	4,104	137	149	3,530	-	-	-	-	-	-	-	-	-	-	-	102	-	-
North Carolina:																				
Rail	-	-	39	-	931	44,212	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	39	-	931	44,243	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota:																				
Rail	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	1,317	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,266	-
Total	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	3,583	-
Ohio:																				
Rail	-	4,316	4,936	-	3,333	25,855	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Water	-	3,619	-	28,438	1,206	25,330	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	1,244	-	23,814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	7	63	227	986	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	9,179	4,943	52,315	4,539	52,171	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Oklahoma:																				
Rail	-	-	-	-	249	633	-	-	-	-	107	219	6,671	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	2,376	-	-	-	-	-	-	-
Total	-	-	-	-	249	633	-	-	-	-	107	219	9,047	-	-	-	-	-	-	-
Oregon: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Pennsylvania:																				
Rail	16,964	13,106	13,824	165	1,806	5,778	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	10,990	-	-	3,222	4,845	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	23,101	9,214	-	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	40,065	33,310	13,824	278	5,028	10,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Carolina: Rail	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota: Rail	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Total	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Tennessee:																				
Rail	-	-	-	-	184	11,951	6,755	1,436	-	-	13	-	62	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	12,040	-	800	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	3,548	49	-	-	-	379	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	184	15,499	18,844	1,436	800	-	392	-	62	-	-	-	-	-	-	-
Texas:																				
Rail	-	-	-	-	780	3,452	-	-	-	-	-	-	27,039	-	-	-	24,848	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	536	523	-	-	-	-	-	-	-	-
Total	-	-	-	-	780	3,452	-	-	-	-	536	523	27,039	-	-	-	24,848	-	-	-

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See footnotes at end of table.

TABLE G-2. - Bituminous coal and lignite distribution for 1985 according to the No. 1 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Utah:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	354	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,974	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	3,328	-	-
Virginia:																				
Rail	11	-	-	-	701	11,328	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	26	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	-	-	-	727	11,464	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[4]3,629
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	3,629
West Virginia:																				
Rail	-	3,295	6,331	1,336	4,737	15,373	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	1,446	1,220	586	-	6,747	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	563	12,447	705	70	1,840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	5,304	19,998	2,627	4,807	23,960	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin:																				
Rail	-	-	-	-	-	601	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Great Lakes	648	-	520	601	245	3,870	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	648	-	520	601	245	4,471	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Wyoming:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,968	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15,274	-	-	-
Canada:																				
Rail	20	-	12	27	88	8,365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	1,681	3,027	7,184	480	2,051	106	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,701	3,027	7,196	507	2,139	8,471	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Mexico: Rail	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Other export: Rail	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-

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[1] Adjusted to provide water service to electric utilities not equipped for rail delivery.
[2] Estimated pipeline capacity.
[3] Tidewater portion included in rail values.
[4] Actual conveyor operations.

TABLE G-3. - Bituminous coal and lignite distribution for 1985 according to the No. 2 constrained modal share analysis

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Alabama:																				
Rail	-	-	-	-	923	1,789	5,020	2,237	-	-	28,094	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	10,689	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	923	1,789	5,020	2,237	-	-	38,783	-	-	-	-	-	-	-	-	-
Arizona: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Arkansas:																				
Rail	-	-	-	-	117	527	-	-	-	-	78	-	7,794	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	-	264	-	-	-	-	-	-	-	-
Total	-	-	-	-	117	527	-	-	-	-	78	264	7,794	-	-	-	-	-	-	-
Colorado:																				
Rail	97	-	-	-	32	68	-	-	-	-	-	-	-	509	8,712	-	6,233	-	2,191	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	741	2,427	-	-	-	-	-
Total	97	-	-	-	32	68	-	-	-	-	-	-	-	1,250	11,139	-	6,233	-	2,191	-
Delaware: Rail	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dist. of Columbia: Rail	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Florida:																				
Rail	-	-	-	-	-	4,398	2,115	507	1,048	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	2,223	-	-	-	949	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	4,398	4,338	507	1,048	-	949	-	-	-	-	-	-	-	-	-
Georgia: Rail	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Idaho:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	37	-	488
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	175	-	488
Illinois:																				
Rail	-	-	32	-	924	4,854	1,099	44,372	246	-	-	125	-	-	37	-	-	-	1,059	-
Water	-	-	-	-	-	-	1,155	-	-	-	-	-	-	-	-	-	-	-	-	11,437
Truck	-	-	-	-	-	-	-	9,767	545	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	32	-	924	4,854	2,254	54,139	791	-	-	125	-	-	37	-	-	-	1,059	11,437
Indiana:																				
Rail	871	1,081	-	10	4,035	9,763	4,204	11,406	25,841	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Water	-	840	-	-	3,009	2,661	4,419	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	50	10,730	-	-	-	-	-	-	-	-	-	-	-
Total	871	1,921	-	10	7,044	12,424	8,623	11,456	36,571	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Iowa:																				
Rail	-	-	-	-	122	28	662	-	46	587	-	-	313	-	35	-	3,253	-	673	8,071
Water	-	-	-	-	-	-	696	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	1,108	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	122	28	1,358	-	46	1,695	-	-	313	-	35	-	3,253	-	673	8,071
Kansas: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Kentucky:																				
Rail	-	-	62	-	345	13,018	3,333	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	8,806	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	736	17,183	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	62	-	345	13,754	29,322	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Louisiana:																				
Rail	-	-	-	-	17	72	-	-	-	-	-	69	2,038	-	-	-	-	-	-	-
Water	-	-	-	-	12	65	-	-	-	-	20	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	29	137	-	-	-	-	20	69	2,038	-	-	-	-	-	-	-
Maryland:																				
Rail	6,024	-	1,053	-	251	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	1,516	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tidewater	1,448	151	913	-	912	6,878	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8,988	151	1,966	-	1,163	7,381	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Massachusetts: Rail	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan:																				
Rail	-	-	5,917	16,884	291	6,953	1,152	99	8	-	-	-	-	-	-	-	-	-	2,311	231
Great Lakes	-	270	3,198	4,657	2,673	12,475	1,802	1,993	625	-	-	-	-	-	-	-	-	-	-	-
Total	-	270	9,115	21,541	2,964	19,428	2,954	2,092	633	-	-	-	-	-	-	-	-	-	2,311	231
Minnesota:																				
Rail	-	-	-	-	-	389	366	-	-	-	-	-	23	-	-	-	225	-	2,938	8,007
Water	-	-	-	-	-	-	385	3,393	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	85	32	451	2,409	-	215	559	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	85	32	451	2,798	751	3,608	559	-	-	-	23	-	-	-	225	-	2,938	8,007

See footnotes at end of table.

TABLE G-3. - Bituminous coal and lignite distribution for 1985 according to the No. 2 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Mississippi:																				
Rail	-	-	-	-	34	116	409	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	26	-	431	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	60	116	840	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Missouri:																				
Rail	-	-	-	-	404	1,341	237	13,484	-	-	140	-	5,523	-	26	-	6,616	-	-	-
Water	-	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	814	-	-	-	-	5,441	-	-	-	-	-	-	-
Total	-	-	-	-	404	1,341	487	14,298	-	-	140	-	10,964	-	26	-	6,616	-	-	-
Montana:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,460
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,561
Nebraska: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Nevada:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,993
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,312	-	-
Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[2]4,800	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-	2,312	-	4,993
New Hampshire: Rail	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey: Rail	[3]874	-	[3]527	4	[3]95	[3]340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	874	-	527	4	95	340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	-	4,958	-	-	4,800
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,799	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	6,799	4,958	-	-	4,800
New York:																				
Rail	5,669	3,840	4,104	137	149	3,317	-	-	-	-	-	-	-	-	-	-	-	102	-	-
Truck	1,630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	10	-	-	-	-	213	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	7,309	3,840	4,104	137	149	3,530	-	-	-	-	-	-	-	-	-	-	-	102	-	-
North Carolina:																				
Rail	-	-	39	-	931	44,212	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	39	-	931	44,243	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota:																				
Rail	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	1,317	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,266	-
Total	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	3,583	-
Ohio:																				
Rail	-	4,479	4,936	8,759	3,508	33,737	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Water	-	3,456	-	19,679	804	17,448	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	1,244	-	23,814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	7	63	227	986	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	9,179	4,943	52,315	4,539	52,171	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Oklahoma:																				
Rail	-	-	-	-	249	633	-	-	-	-	107	219	6,671	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	2,376	-	-	-	-	-	-	-
Total	-	-	-	-	249	633	-	-	-	-	107	219	9,047	-	-	-	-	-	-	-
Oregon: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Pennsylvania:																				
Rail	16,964	13,612	13,824	165	2,880	5,998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	10,484	-	-	2,148	4,625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	23,101	9,214	-	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	40,065	33,310	13,824	278	5,028	10,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Carolina: Rail	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota: Rail	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Total	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Tennessee:																				
Rail	-	-	-	-	184	11,951	9,163	1,436	-	-	13	-	62	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	9,632	-	800	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	3,548	49	-	-	-	379	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	184	15,499	18,844	1,436	800	-	392	-	62	-	-	-	-	-	-	-
Texas:																				
Rail	-	-	-	-	780	3,452	-	-	-	-	-	-	27,039	-	-	-	24,848	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	536	523	-	-	-	-	-	-	-	-
Total	-	-	-	-	780	3,452	-	-	-	-	536	523	27,039	-	-	-	24,848	-	-	-

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See footnotes at end of table.

TABLE G-3. - Bituminous coal and lignite distribution for 1985 according to the No. 2 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Utah:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	354	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,974	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	3,328	-	-
Virginia:																				
Rail	11	-	-	-	701	11,328	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	26	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	-	-	-	727	11,464	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[4]3,629
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	3,629
West Virginia:																				
Rail	-	3,295	6,331	1,336	4,737	15,373	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	1,446	1,220	586	-	6,747	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	563	12,447	705	70	1,840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	5,304	19,998	2,627	4,807	23,960	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin:																				
Rail	-	-	-	-	-	601	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Great Lakes	648	-	520	601	245	3,870	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	648	-	520	601	245	4,471	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Wyoming:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,968	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15,274	-	-	-
Canada:																				
Rail	20	-	12	27	88	8,365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	1,681	3,027	7,184	480	2,051	106	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,701	3,027	7,196	507	2,139	8,471	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Mexico: Rail	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Other export: Rail	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-

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[1] Adjusted to provide water service to electric utilities not equipped for rail delivery.

[2] Estimated pipeline capacity.

[3] Tidewater portion included in rail values.

[4] Actual conveyor operation.

TABLE G-4. - Bituminous coal and lignite distribution for 1985 according to the No. 3 constrained modal share analysis

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Alabama																				
Rail	-	-	-	-	923	1,789	5,020	2,237	-	-	28,094	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	10,689	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	923	1,789	5,020	2,237	-	-	38,783	-	-	-	-	-	-	-	-	-
Arizona: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,936	-	2,037	-	-
Arkansas:																				
Rail	-	-	-	-	117	527	-	-	-	-	78	-	7,794	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	-	264	-	-	-	-	-	-	-	-
Total	-	-	-	-	117	527	-	-	-	-	78	264	7,794	-	-	-	-	-	-	-
Colorado:																				
Rail	97	-	-	-	32	68	-	-	-	-	-	-	-	509	8,712	-	6,233	-	2,191	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	741	2,427	-	-	-	-	-
Total	97	-	-	-	32	68	-	-	-	-	-	-	-	1,250	11,139	-	6,233	-	2,191	-
Delaware: Rail	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	798	21	285	-	636	1,065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dist. of Columbia: Rail	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	-	151	-	55	1,053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Florida:																				
Rail	-	-	-	-	-	4,398	1,559	507	1,048	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	2,779	-	-	-	949	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	4,398	4,338	507	1,048	-	949	-	-	-	-	-	-	-	-	-
Georgia: Rail	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	11,594	11,438	1,339	2,763	-	2,499	-	-	-	-	-	-	-	-	-
Idaho:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	37	-	488
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92	175	-	488
Illinois:																				
Rail	-	-	32	-	924	4,854	810	44,372	246	-	-	125	-	-	37	-	-	-	1,059	-
Water	-	-	-	-	-	-	1,444	-	-	-	-	-	-	-	-	-	-	-	-	[1]11,437
Truck	-	-	-	-	-	-	-	9,767	545	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	32	-	924	4,854	2,254	54,139	791	-	-	125	-	-	37	-	-	-	1,059	11,437
Indiana:																				
Rail	871	1,554	-	10	2,530	7,564	3,099	11,406	25,841	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Water	-	367	-	-	4,514	4,168	5,524	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	50	10,730	-	-	-	-	-	-	-	-	-	-	-
Total	871	1,921	-	10	7,044	12,424	8,623	11,456	36,571	-	-	-	-	-	-	-	2,511	-	1,218	3,205
Iowa:																				
Rail	-	-	-	-	122	28	488	-	46	587	-	-	313	-	35	-	3,253	-	673	8,071
Water	-	-	-	-	-	-	870	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	1,108	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	122	28	1,358	-	46	1,695	-	-	313	-	35	-	3,253	-	673	8,071
Kansas: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	618	-	10,507	-	-	-
Kentucky:																				
Rail	-	-	62	-	345	13,018	1,132	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	11,007	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	736	17,183	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	62	-	345	13,754	29,322	5,860	936	-	-	-	-	-	-	-	-	-	-	-
Louisiana:																				
Rail	-	-	-	-	10	35	-	-	-	-	-	69	2,038	-	-	-	-	-	-	-
Water	-	-	-	-	19	102	-	-	-	-	20	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	29	137	-	-	-	-	20	69	2,038	-	-	-	-	-	-	-
Maryland:																				
Rail	6,024	-	1,053	-	251	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	1,516	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tidewater	1,448	151	913	-	912	6,878	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	8,988	151	1,966	-	1,163	7,381	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Massachusetts: Rail	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	29	-	50	-	21	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Michigan:																				
Rail	-	-	5,917	16,884	291	6,953	1,152	99	8	-	-	-	-	-	-	-	-	-	2,311	231
Great Lakes	-	270	3,198	4,657	2,673	12,475	1,802	1,993	625	-	-	-	-	-	-	-	-	-	-	-
Total	-	270	9,115	21,541	2,964	19,428	2,954	2,092	633	-	-	-	-	-	-	-	-	-	2,311	231
Minnesota:																				
Rail	-	-	-	-	-	389	270	-	-	-	-	-	23	-	-	-	225	-	2,938	8,007
Water	-	-	-	-	-	-	481	3,393	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	85	32	451	2,409	-	215	559	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	85	32	451	2,798	751	3,608	559	-	-	-	23	-	-	-	225	-	2,938	8,007

See footnotes at end of table.

TABLE G-4. - Bituminous coal and lignite distribution for 1985 according to the No. 3 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Mississippi:																				
Rail	-	-	-	-	22	116	302	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Water	-	-	-	-	38	-	538	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	60	116	840	146	-	-	2,021	-	-	-	-	-	-	-	-	-
Missouri:																				
Rail	-	-	-	-	404	1,341	175	13,484	-	-	140	-	5,523	-	26	-	6,616	-	-	-
Water	-	-	-	-	-	-	312	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	814	-	-	-	-	5,441	-	-	-	-	-	-	-
Total	-	-	-	-	404	1,341	487	14,298	-	-	140	-	10,964	-	26	-	6,616	-	-	-
Montana:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,460
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,280	-	-	9,561
Nebraska: Rail	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Total	-	-	-	-	-	-	-	-	-	-	-	19	-	-	645	-	3,461	-	-	7,451
Nevada:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,993
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,312	-	-
Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[2]4,800	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,800	-	2,312	-	4,993
New Hampshire: Rail	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	14	-	2	1,730	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Jersey: Rail	[3]874	-	[3]527	4	[3]95	[3]340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	874	-	527	4	95	340	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Mexico:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	-	4,958	-	-	4,800
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,799	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	28	-	-	-	6,799	4,958	-	-	4,800
New York:																				
Rail	5,669	3,840	4,104	137	149	3,317	-	-	-	-	-	-	-	-	-	-	-	102	-	-
Truck	1,630	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	10	-	-	-	-	213	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	7,309	3,840	4,104	137	149	3,530	-	-	-	-	-	-	-	-	-	-	-	102	-	-
North Carolina:																				
Rail	-	-	39	-	931	44,212	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	39	-	931	44,243	-	-	-	-	-	-	-	-	-	-	-	-	-	-
North Dakota:																				
Rail	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	1,317	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,266	-
Total	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	250	-	3,583	-
Ohio:																				
Rail	-	6,412	4,936	22,984	3,106	23,854	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Water	-	1,523	-	5,454	1,206	27,331	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	1,244	-	23,814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	-	-	7	63	227	986	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	9,179	4,943	52,315	4,539	52,171	-	-	828	-	-	-	-	-	-	-	-	-	-	-
Oklahoma:																				
Rail	-	-	-	-	249	633	-	-	-	-	107	219	6,671	-	-	-	-	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	2,376	-	-	-	-	-	-	-
Total	-	-	-	-	249	633	-	-	-	-	107	219	9,047	-	-	-	-	-	-	-
Oregon: Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	99
Pennsylvania:																				
Rail	16,964	19,475	13,824	165	1,806	8,586	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	4,621	-	-	3,222	2,037	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	23,101	9,214	-	113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	40,065	33,310	13,824	278	5,028	10,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Carolina: Rail	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	12,781	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Dakota: Rail	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Total	-	-	-	3	-	23	9	-	-	-	-	-	-	-	-	-	912	-	13,136	-
Tennessee:																				
Rail	-	-	-	-	184	11,951	6,755	1,436	-	-	13	-	62	-	-	-	-	-	-	-
Water	-	-	-	-	-	-	12,040	-	800	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	-	3,548	49	-	-	-	379	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	184	15,499	18,844	1,436	800	-	392	-	62	-	-	-	-	-	-	-
Texas:																				
Rail	-	-	-	-	780	3,452	-	-	-	-	-	-	27,039	-	-	-	24,848	-	-	-
Water	-	-	-	-	-	-	-	-	-	-	536	523	-	-	-	-	-	-	-	-
Total	-	-	-	-	780	3,452	-	-	-	-	536	523	27,039	-	-	-	24,848	-	-	-

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See footnotes at end of table.

TABLE G-4. - Bituminous coal and lignite distribution for 1985 according to the No. 3 constrained modal share analysis--Continued

(Thousand short tons)

Consumer region and method of movement	Origin districts																			
	1	2	3+6	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22+23
Utah:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	354	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,974	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,938	3,328	-	-
Virginia:																				
Rail	11	-	-	-	701	11,328	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	-	-	-	26	136	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	-	-	-	727	11,464	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Washington:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[4]3,629
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	157	-	3,629
West Virginia:																				
Rail	-	3,295	6,331	1,336	4,737	15,373	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	1,446	1,220	586	-	6,747	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	-	563	12,447	705	70	1,840	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	5,304	19,998	2,627	4,807	23,960	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wisconsin:																				
Rail	-	-	-	-	-	601	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Great Lakes	648	-	520	601	245	3,870	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	648	-	520	601	245	4,471	-	-	-	-	-	-	-	-	-	-	1,023	-	7,986	11,248
Wyoming:																				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,306	-	-	-
Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13,968	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15,274	-	-	-
Canada:																				
Rail	20	-	12	27	88	8,365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Lakes	1,681	3,027	7,184	480	2,051	106	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1,701	3,027	7,196	507	2,139	8,471	143	-	-	-	-	-	-	-	-	-	-	-	-	-
Mexico: Rail	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	182	-	-	-	259	-	-	-	-	-	-	-	-
Other export: Rail	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3,955	-	2,478	-	-	19,384	25,558	-	-	-	-	-	-	-	-	-	-	-	-	-

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[1] Adjusted to provide water service to electric utilities not equipped for rail delivery.
[2] Estimated pipeline capacity.
[3] Tidewater portion included in rail values.
[4] Actual conveyor operation.

TABLE G-5. - Projected 1985 coal transport shares for the unconstrained modal share, by State, million short tons

State	Truck	Rail	Water	Tide-water	Great Lakes	Pipe-line	Total
Alabama................	10,689	38,063	-	-	-	-	48,752
Arizona................	-	13,973	-	-	-	-	13,973
Arkansas...............	-	8,516	264	-	-	-	8,780
Colorado...............	3,168	17,842	-	-	-	-	21,010
Delaware...............	-	2,805	-	-	-	-	2,805
District of Columbia...	-	1,314	-	-	-	-	1,314
Florida................	-	5,953	5,287	-	-	-	11,240
Georgia................	-	29,633	-	-	-	-	29,633
Idaho..................	138	617	-	-	-	-	755
Illinois...............	10,312	51,649	13,691	-	-	-	75,652
Indiana................	10,780	51,905	23,169	-	-	-	85,854
Iowa...................	1,108	13,128	1,358	-	-	-	15,594
Kansas.................	-	11,144	-	-	-	-	11,144
Kentucky...............	17,919	20,221	12,139	-	-	-	50,279
Louisiana..............	-	2,107	186	-	-	-	2,293
Maryland...............	1,516	7,831	-	10,302	-	-	19,649
Massachusetts..........	-	113	-	-	-	-	113
Michigan...............	-	33,846	-	-	27,693	-	61,539
Minnesota..............	-	11,582	4,144	-	3,751	-	19,477
Mississippi............	-	2,283	900	-	-	-	3,183
Missouri...............	6,255	27,534	487	-	-	-	34,276
Montana................	101	10,740	-	-	-	-	10,841
Nebraska...............	-	11,576	-	-	-	-	11,576
Nevada.................	2,312	4,993	-	-	-	4,800	12,105
New Hampshire..........	-	1,774	-	-	-	-	1,774
New Jersey.............	-	1,840	-	-	-	-	1,840
New Mexico.............	6,799	9,786	-	-	-	-	16,585
New York...............	1,630	17,318	-	-	223	-	19,171
North Carolina.........	31	45,182	-	-	-	-	45,213
North Dakota...........	2,266	1,579	-	-	-	-	3,845
Ohio...................	25,058	22,787	74,847	-	1,283	-	123,975
Oklahoma...............	2,376	7,879	-	-	-	-	10,255
Oregon.................	-	106	-	-	-	-	106
Pennsylvania...........	32,428	30,953	39,747	-	-	-	103,128
South Carolina.........	-	12,781	-	-	-	-	12,781
South Dakota...........	-	14,083	-	-	-	-	14,083
Tennessee..............	3,976	13,646	19,595	-	-	-	37,217
Texas..................	-	56,119	1,059	-	-	-	57,178
Utah...................	2,974	7,292	-	-	-	-	10,266
Virginia...............	162	12,040	-	-	-	-	12,202
Washington.............	3,629	258	-	-	-	-	3,887
West Virginia..........	15,625	8,289	32,782	-	-	-	56,696
Wisconsin..............	-	20,858	-	-	5,884	-	26,742
Wyoming................	13,968	1,306	-	-	-	-	15,274
Canada.................	-	8,512	-	-	14,672	-	23,184
Mexico.................	-	441	-	-	-	-	441
Other export...........	-	51,375	-	-	-	-	51,375
Total............	175,220	725,572	229,655	10,302	53,506	4,800	1,199,055

TABLE G-6. - Projected 1985 coal transport shares for the No. 1 constrained modal share, by State, million short tons

State	Truck	Rail	Water	Tide-water	Great Lakes	Pipe-line	Total
Alabama................	10,689	38,063	-	-	-	-	48,752
Arizona................	-	13,973	-	-	-	-	13,973
Arkansas...............	-	8,516	264	-	-	-	8,780
Colorado...............	3,168	17,842	-	-	-	-	21,010
Delaware...............	-	2,805	-	-	-	-	2,805
District of Columbia...	-	1,314	-	-	-	-	1,314
Florida................	-	7,512	3,728	-	-	-	11,240
Georgia................	-	29,633	-	-	-	-	29,633
Idaho..................	138	617	-	-	-	-	755
Illinois...............	10,312	52,459	12,881	-	-	-	75,652
Indiana................	10,780	60,297	14,777	-	-	-	85,854
Iowa...................	1,108	13,616	870	-	-	-	15,594
Kansas.................	-	11,144	-	-	-	-	11,144
Kentucky...............	17,919	21,353	11,007	-	-	-	50,279
Louisiana..............	-	2,159	134	-	-	-	2,293
Maryland...............	1,516	7,831	-	10,302	-	-	19,649
Massachusetts..........	-	113	-	-	-	-	113
Michigan...............	-	33,846	-	-	27,693	-	61,539
Minnesota..............	-	11,852	3,874	-	3,751	-	19,477
Mississippi............	-	2,607	576	-	-	-	3,183
Missouri...............	6,255	27,709	312	-	-	-	34,276
Montana................	101	10,740	-	-	-	-	10,841
Nebraska...............	-	11,576	-	-	-	-	11,576
Nevada.................	2,312	4,993	-	-	-	4,800	12,105
New Hampshire..........	-	1,774	-	-	-	-	1,774
New Jersey.............	-	1,840	-	-	-	-	1,840
New Mexico.............	6,799	9,786	-	-	-	-	16,585
New York...............	1,630	17,318	-	-	223	-	19,171
North Carolina.........	31	45,182	-	-	-	-	45,213
North Dakota...........	2,266	1,579	-	-	-	-	3,845
Ohio...................	25,058	39,268	58,593	-	1,283	-	124,202
Oklahoma...............	2,376	7,879	-	-	-	-	10,255
Oregon.................	-	106	-	-	-	-	106
Pennsylvania...........	32,428	51,643	19,057	-	-	-	103,128
South Carolina.........	-	12,781	-	-	-	-	12,781
South Dakota...........	-	14,083	-	-	-	-	14,083
Tennessee..............	3,976	20,401	12,840	-	-	-	37,217
Texas..................	-	56,119	1,059	-	-	-	57,178
Utah...................	2,974	7,292	-	-	-	-	10,266
Virginia...............	162	12,040	-	-	-	-	12,202
Washington.............	3,629	258	-	-	-	-	3,887
West Virginia..........	15,625	31,072	9,999	-	-	-	56,696
Wisconsin..............	-	20,858	-	-	5,884	-	26,742
Wyoming................	13,968	1,306	-	-	-	-	15,274
Canada.................	-	8,512	-	-	14,672	-	23,184
Mexico.................	-	441	-	-	-	-	441
Other export...........	-	51,375	-	-	-	-	51,375
Total............	175,220	805,483	149,971	10,302	53,506	4,800	1,199,282

TABLE G-7. - Projected 1985 coal transport shares for the No. 2 constrained modal share, by State, million short tons

State	Truck	Rail	Water	Tide-water	Great Lakes	Pipe-line	Total
Alabama................	10,689	38,063	-	-	-	-	48,752
Arizona................	-	13,973	-	-	-	-	13,973
Arkansas...............	-	8,516	264	-	-	-	8,780
Colorado...............	3,168	17,842	-	-	-	-	21,010
Delaware...............	-	2,805	-	-	-	-	2,805
District of Columbia...	-	1,314	-	-	-	-	1,314
Florida................	-	8,068	3,172	-	-	-	11,240
Georgia................	-	29,633	-	-	-	-	29,633
Idaho..................	138	617	-	-	-	-	755
Illinois...............	10,312	52,748	12,592	-	-	-	75,652
Indiana................	10,780	64,145	10,929	-	-	-	85,854
Iowa...................	1,108	13,790	696	-	-	-	15,594
Kansas.................	-	11,144	-	-	-	-	11,144
Kentucky...............	17,919	23,554	8,806	-	-	-	50,279
Louisiana..............	-	2,196	97	-	-	-	2,293
Maryland...............	1,516	7,831	-	10,302	-	-	19,649
Massachusetts..........	-	113	-	-	-	-	113
Michigan...............	-	33,846	-	-	27,693	-	61,539
Minnesota..............	-	11,948	3,778	-	3,751	-	19,477
Mississippi............	-	2,726	457	-	-	-	3,183
Missouri...............	6,255	27,771	250	-	-	-	34,276
Montana................	101	10,740	-	-	-	-	10,841
Nebraska...............	-	11,576	-	-	-	-	11,576
Nevada.................	2,312	4,993	-	-	-	4,800	12,105
New Hampshire..........	-	1,774	-	-	-	-	1,774
New Jersey.............	-	1,840	-	-	-	-	1,840
New Mexico.............	6,799	9,786	-	-	-	-	16,585
New York...............	1,630	17,318	-	-	223	-	19,171
North Carolina.........	31	45,182	-	-	-	-	45,213
North Dakota...........	2,266	1,579	-	-	-	-	3,845
Ohio...................	25,058	56,247	41,387	-	1,283	-	123,975
Oklahoma...............	2,376	7,879	-	-	-	-	10,255
Oregon.................	-	106	-	-	-	-	106
Pennsylvania...........	32,428	53,443	17,257	-	-	-	103,128
South Carolina.........	-	12,781	-	-	-	-	12,781
South Dakota...........	-	14,083	-	-	-	-	14,083
Tennessee..............	3,976	22,809	10,432	-	-	-	37,217
Texas..................	-	56,119	1,059	-	-	-	57,178
Utah...................	2,974	7,292	-	-	-	-	10,266
Virginia...............	162	12,040	-	-	-	-	12,202
Washington.............	3,629	258	-	-	-	-	3,887
West Virginia..........	15,625	31,072	9,999	-	-	-	56,696
Wisconsin..............	-	20,858	-	-	5,884	-	26,742
Wyoming................	13,968	1,306	-	-	-	-	15,274
Canada.................	-	8,512	-	-	14,672	-	23,184
Mexico.................	-	441	-	-	-	-	441
Other export...........	-	51,375	-	-	-	-	51,375
Total............	175,220	834,052	121,175	10,302	53,506	4,800	1,199,055

TABLE G-8. - Projected 1985 coal transport shares for the No. 3 constrained modal share, by State, million short tons

State	Truck	Rail	Water	Tide-water	Great Lakes	Pipe-line	Total
Alabama..............	10,689	38,063	-	-	-	-	48,752
Arizona..............	-	13,973	-	-	-	-	13,973
Arkansas.............	-	8,516	264	-	-	-	8,780
Colorado.............	3,168	17,842	-	-	-	-	21,010
Delaware.............	-	2,805	-	-	-	-	2,805
District of Columbia..	-	1,314	-	-	-	-	1,314
Florida..............	-	7,512	3,728	-	-	-	11,240
Georgia..............	-	29,633	-	-	-	-	29,633
Idaho................	138	617	-	-	-	-	755
Illinois.............	10,312	52,459	12,881	-	-	-	75,652
Indiana..............	10,780	59,809	14,573	-	-	-	85,162
Iowa.................	1,108	13,616	870	-	-	-	15,594
Kansas...............	-	11,144	-	-	-	-	11,144
Kentucky.............	17,919	21,353	11,007	-	-	-	50,279
Louisiana............	-	2,152	141	-	-	-	2,293
Maryland.............	1,516	7,831	-	10,302	-	-	19,649
Massachusetts........	-	113	-	-	-	-	113
Michigan.............	-	33,846	-	-	27,693	-	61,539
Minnesota............	-	11,852	3,874	-	3,751	-	19,477
Mississippi..........	-	2,607	576	-	-	-	3,183
Missouri.............	6,255	27,709	312	-	-	-	34,276
Montana..............	101	10,740	-	-	-	-	10,841
Nebraska.............	-	11,576	-	-	-	-	11,576
Nevada...............	2,312	4,993	-	-	-	4,800	12,105
New Hampshire........	-	1,774	-	-	-	-	1,774
New Jersey...........	-	1,840	-	-	-	-	1,840
New Mexico...........	6,799	9,786	-	-	-	-	16,585
New York.............	1,630	17,318	-	-	223	-	19,171
North Carolina.......	31	45,182	-	-	-	-	45,213
North Dakota.........	2,266	1,579	-	-	-	-	3,845
Ohio.................	25,058	62,120	35,514	-	1,283	-	123,975
Oklahoma.............	2,376	7,879	-	-	-	-	10,255
Oregon...............	-	106	-	-	-	-	106
Pennsylvania.........	32,428	60,820	9,880	-	-	-	103,128
South Carolina.......	-	12,781	-	-	-	-	12,781
South Dakota.........	-	14,083	-	-	-	-	14,083
Tennessee............	3,976	20,401	12,840	-	-	-	37,217
Texas................	-	56,119	1,059	-	-	-	57,178
Utah.................	2,974	7,292	-	-	-	-	10,266
Virginia.............	162	12,040	-	-	-	-	12,202
Washington...........	3,629	258	-	-	-	-	3,887
West Virginia........	15,625	31,072	9,999	-	-	-	56,696
Wisconsin............	-	20,858	-	-	5,884	-	26,742
Wyoming..............	13,968	1,306	-	-	-	-	15,274
Canada...............	-	8,512	-	-	14,672	-	23,184
Mexico...............	-	441	-	-	-	-	441
Other export.........	-	51,375	-	-	-	-	51,375
Total...........	175,220	837,017	117,518	10,302	53,506	4,800	1,198,363

APPENDIX H.--DEFINITIONS

Average practice.--In reference to transportation costs, this terminology represents the least squares calculated line of best fit for selected coal transportation cost data. In a discussion of operating characteristics, it pertains to the average values for equipment operation generated in an analysis of carrier practices in 1973.

Best practice.--A method of transportation that, through the application of new technology and the efficient use of existing transport facilities, utilizes coal haulage equipment in such a manner as to minimize lag/idle time and maximize annual carrying capacity.

Class I railroads.--Those railroads having annual operating revenues of $5,000,000 or more (2).

Constrained modal share.--A total origin-destination matrix portraying the effects of river capacity constraints on the allocation of projected 1985 coal tonnages to the modes of delivery serving each individual origin-destination.

Eastern, southern, western districts (as applied to rail transporation).--These are not geographic divisions as the names imply. Rather, rail districts are formed by a compilation of select roads. For further information, see reference 27.

Ex-river shipments.--Bureau of Mines terminology that "Includes coal loaded directly into river barges at the mine and coal hauled to river dumping facilities via rail, truck, or other means of transport and thence shipped via river to a river lifting facility from which the coal was transshipped inland to the ultimate consumer or retail dealer located away from the river lifting facility" (55).

Interlining service.--An occurrence in single-mode transportation where two or more carriers are required to complete the transmission of freight from origin to destination.

Serviceable hopper cars.--The number of hopper cars remaining when those awaiting repairs are subtracted from total hopper car ownership.

Unconstrained modal share.--A total origin-destination matrix displaying the projected 1985 coal tonnages allocated to each of the proportionally increased modes along with the initial coal tonnages given to the least cost choice between water and rail (if both are available).

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